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BUILDING AND PUBLIC WORKS
ADMINISTRATION, ESTIMATING AND COSTING

Building & Public Works Administration, Estimating & Costing

For the use of Civil Engineers, Surveyors,
and Building Contractors

BY

SPENCE GEDDES

E.S.Diplomate, R.T.C., Glasgow

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DEDICATED
TO MY FATHER
GEORGE GEDDES, J.P., M.B.E.
QUARRYMASTER AND CONTRACTOR
1858-1937

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PREFACE

"BUILDING and Public Works Administration, Estimating and Costing" was first published in 1946. The second edition appeared in 1948, and when, in 1950, the third edition was published, the opportunity was taken to revise the book as a whole, bringing some of the tabulated information right up to date, and extending considerably the scope of the Sections dealing with Brickwork and Excavation. A new Section on Bonus as an Incentive to Higher Output was also added.

The object of this book is to make available in one volume a book of reference on Building and Civil Engineering Practice as applied to the efficient administration of the works of construction, estimating the cost of the work, tendering for work, and costing the works of construction under the various component operations.

To be of general use a work such as this should be suitable not only for the builder and contractor but also for the architect, engineer, surveyor and student. Every endeavour has been made to ensure that the informative matter contained in this book comes under this category so that all those interested may find it of use in whichever sphere they operate.

The information it contains covers those points which I, as a young man failed to find in the various books I perused, and I know from experience that many young engineers and surveyors have difficulty in obtaining information on some of their problems through the medium of a book. Such problems are connected with:

1. How to organise and administer the works of construction, programming and progressing the work, assessing the staff, plant and labour required, etc.
2. What are the normal or "Basic Outputs" of plant and labour in carrying out various operations and classes of work.
3. What is the correct apportionment of labour to plant and to tradesmen in carrying out various operations and classes of work.
4. How to evolve and operate bonus systems of payment as an incentive to higher output.
5. How to determine the plant and labour unit costs of the work.
6. "Establishment Charges" and how to allow for them in estimating.
7. How to estimate the "Total Cost of the Work" and how to "Tender for Work" where the element of "Profit" has to be allowed for.

The fundamentals involved in connection with the foregoing have been dealt with in as clear and concise a manner as possible so that no difficulty should be experienced in grasping the essentials.

For speed of reference the data shown for estimating purposes have been laid out under various "Trade Sections" in each of which are shown tabulated data from which to estimate the unit cost of the work concerned. These tables show the plant and labour hours taken to carry out one unit of the work in question and, being "Hour Constants" shown in decimal parts of an hour, they are in no way affected by any fluctuation in plant working costs or labour rates of pay per hour. The information shown in the estimating tables is therefore always "up to date". To compute the cost of the unit of work the plant and labour hours shown are simply extended by the prevailing plant and labour rates.

In estimating, many variables have to be considered, e.g. the quality of labour differs, one man works harder and produces more in a given time than another, weather conditions affect output, etc., so that in estimating it is necessary to do so on "fair average" plant and labour outputs and "fair average" costs.

The "Hour Constants" shown allow for this, the main items having been produced from recorded data, and "fair average" costs of similar works carried out.

It is the author's hope that this book will be of use to all who are interested and that in it those whose experience is still limited may find the answer to many of the problems with which they are certain to be confronted.

The author's grateful acknowledgments are due to those manufacturers who so readily placed at his disposal information and photographs in connection with their products and also to those who granted permission to reproduce certain tables of useful data which have been included in various sections of this work.

S. GEDDES

Ruddock and Meighan Ltd.,
Civil Engineering Contractors,
London.

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BUILDING AND PUBLIC WORKS ADMINISTRATION, ESTIMATING AND COSTING

SECTION ONE

★

GENERAL

In connection with Site Administration, Organising and Running the Work the following are the main points which have to be aimed at:

1. Sound workmanship.
2. Work constructed at a fast rate of progress.
3. Work constructed at a low cost.

In order to achieve this, various factors in connection with organising the work have to be co-ordinated so that the whole is balanced. The work will then run sweetly and smoothly with the resultant large output at low cost. On the other hand, if these are not attended to chaos will probably result and the job will neither progress nor make a profit.

Points which must be attended to are as follows:

1. THE PLANT arranged for the job must be suitable for the work it has to do and must be sound and capable of performing the work with the minimum of time lost in carrying out repairs, etc.
2. THE LABOUR must be apportioned to the plant correctly in order to keep it working to capacity with no excess of labour idling.
3. THE MATERIAL INTAKE to the job must be such, as regards rate of delivery, that all plant is kept working to capacity.
4. PROGRAMME OF WORKS must be drawn up so that work may be started at the correct time, and in the correct sequence to ensure all work being completed in the specified time.
5. THE STAFF put in charge of the administration must be experienced in the class of work to be constructed.
6. CO-ORDINATION OF WORK AS A WHOLE is vital to the success of the contract from all points of view, i.e. workmanship, rate of progress, and cost.

The above points are dealt with under various sections throughout the book. Those sections devoted to: (*a*) Administration Points of Importance for the Agent in Charge (Section Seven); (*b*) How to apportion Labour to Plant and Labour to Tradesmen in Constructing Various Works (Section Eight); are probably those which the agent and his engineer in charge of construction will find most useful.

Estimating for Civil Engineering Works of Construction

In order to produce sound estimates, one must know the average cost of various kinds of work. Various factors will influence the making up of a tender.

1. Quality of labour and labour output varies in different localities.
2. Weather conditions greatly affect output.

3. Ground conditions vary. The excavation may be dry, wet, hard, soft, shallow or deep.
4. The work may be in open ground such as fields or it may be in congested areas such as public roads, necessitating extensive watching, lighting, flagging of traffic, double handling of materials, etc.
5. The availability of a plentiful and near supply of good water.
6. The availability of a plentiful supply of materials of good quality.
7. Access to the site may be good; on the other hand it may be poor and temporary roads may be required.
8. Some authorities and individuals show more consideration to the contractor than do others.

The experienced estimator takes such factors into account and makes allowance for them when preparing the tender. He can count on past experience to guide him and can judge when a job is worth that little bit more. Experience alone can give this judgment.

It would almost appear to the average man that there are so many "variables" that it would be next to impossible to compile a tender, but tenders *are* produced from average costs of various works. These costs have been taken over a period of many years under varying conditions, and strike a "fair average" as it were, allowing for all normal contingencies. These are the costs which are tabulated in this book for tendering purposes.

In the case of particularly awkward contracts where the work presents abnormal difficulties, the estimator must use his initiative and imagination to allow for these difficulties by increasing his tender over and above the normal, this increase being sufficient to cover all difficulties.

FACTORS WHICH INFLUENCE THE MAKING-UP OF A SOUND TENDER

Plant and Labour Costs

To produce an accurate and sound tender it must be based on actual average costs of works constructed of a similar nature. Furthermore, having secured the work, when construction is started, it should be carried out with a similar apportionment of labour to plant as was used on the works from which these actual costs were produced. There is, for example, little chance of the actual plant and labour cost on the work itself for concreting a road being as estimated if the engineer in charge of the work used a 14/10 concrete mixer and 12 men handling 5 cubic yards of finished concrete per hour, if, when making up the estimate, the estimator based his "price make up" on a 14/10 mixer and 8 men handling 5 cubic yards of concrete per hour.

It is for this reason that this book embodies the following:

1. Cost hour constants for constructing various works.
2. The labour apportionment to the plant and to tradesmen in constructing various kinds of work.
3. The materials which various plants will handle per hour, i.e. the plant output per hour.

The above, as shown, follows and adheres to the usual code of practice and has been carefully worked out to produce *steady output at low cost.*

Note.—The labour hour constants shown under the various sections allow for all off-loading from lorries and laying complete in the work.

Material Delivery

The rate of material delivery is most important both in producing the tender and in constructing the work. It is essential that the plant is fed with materials to capacity to produce work at low cost, thus ensuring that with the labour correctly apportioned to the plant, the work goes steadily on with no stoppage.

The estimator at the time of tendering is advised to get not only the price of materials delivered to the site, but also the guaranteed rate of delivery, and tender accordingly. If the work is to be carried out economically, the plant used must be worked to capacity, as it will be realised that if a roller, say, can roll 10 cubic yards of material per hour and only 5 cubic yards are delivered, the cost of rolling is doubled. The graph in Fig. 1 illustrates how the Plant Cost per unit of work can soar if the plant is not fed to capacity.

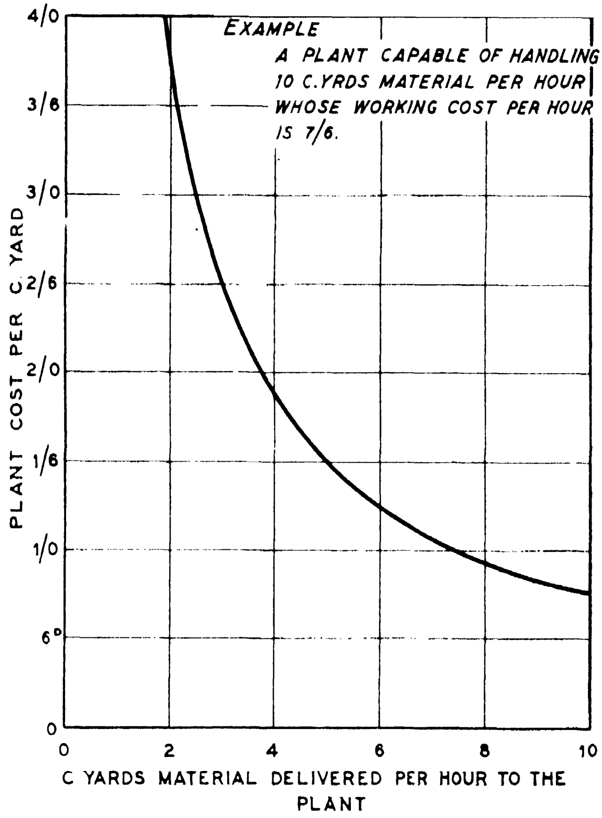

FIG. 1.—GRAPH SHOWING HOW PLANT COSTS PER UNIT CAN BE EXCESSIVELY HIGH IF PLANT IS NOT SUPPLIED WITH MATERIALS TO ITS CAPACITY

Note.—This applies to all plant and also greatly affects labour costs. Labour is not kept fully employed if plant is not working to capacity.

Cost Hour Constants shown in Tables for use in Estimating

The plant and labour constants are shown as hours taken to construct the unit of work and when extended by the monetary rates prevailing represent the *cost of producing the unit of work* and NOT *the tendering rate.* To the cost figure arrived at has to be added a percentage of sufficient amount to show a profit.

Under various sections throughout this book all the above points are dealt with.

Those sections devoted to: Head Office and General Site Charges and the Profit (Section Two); Costing the Work (Section Three); How to Tender (Section Four); How to use the Estimating Tables (Section Five), show clearly how to use the tables for estimating.

SECTION TWO

★

HEAD OFFICE AND GENERAL SITE CHARGES

The elements, apart from the Plant Labour and Material Cost, which constitute the cost of work may be divided into two classes, as set out below.

The Elements which constitute the Cost of Work

1. Those which are allowed for by adding a percentage addition to the estimated Plant Labour and Material Cost as computed from the estimating tables. These elements are Head Office and General Site Charges, or, as they are often called, Establishment Charges. Examples of these and of how to make the percentage addition to allow for them are shown later in this Section.
2. Those elements of the cost which may be necessary on one contract but are not necessary on another. Such elements are, Watching and Lighting, Controlling Traffic by Flagmen, "Stop" and "Go" Boards, etc. For such items as these the estimator must assess for how long they will be necessary on the particular contract and compute a figure to allow for their cost. In the case of a Guarantee Bond for the due performance of the contract, a firm quotation can be had for this from an Insurance Company. The cost of these items may be allowed either as lump sums, or by increasing the tendering rates as worked out to an amount sufficient to cover their cost plus a percentage to allow for Establishment Charges and Profit.

The Percentage Addition to make to the Estimated Cost of the Unit of Work to allow for small Plant and Tools

Small plant and tools consist of such items as barrows, ropes, ladders, steps, trestles, picks, tackle, scaffold poles and boards, putlogs, hoses, saws, pails, fencing pins, watching lamps, tool boxes, etc. These are looked upon as a General Site Charge and their cost is allowed for as a percentage addition to the estimated cost of the Work or Unit of Work as calculated from the estimating tables shown under the various trade sections, this percentage addition being included under Establishment Charges. The amount of the percentage addition to make depends on the class of work being carried out and is greater in the case of Building Works than in Civil Engineering Works.

The table on page 15 gives the percentage addition to allow for small plant and tools for both Civil Engineering and Building Works. Fair average allowances are represented and the estimator may use them as they stand, as they are reasonably accurate for estimating purposes. He can, of course, assess for himself should he so desire, what percentage of the cost the small plant and tools would be for any particular contract being tendered for, making due allowance for the recovery value of any of the tools on completion.

The Percentage Addition to make to the Estimated Cost of the Unit of Work to allow for Insurance

The employer is responsible for all Insurance Costs under the Fatal Accidents Act, Employer's Liability, National Insurance (Industrial Injuries) and National Insurance Acts. These are the usual insurances allowed for in estimating and, with the exception of National Insurance they can be covered by insurance policies. These policies are generally charged for as a percentage of the wages paid on the contract, the total premium usually being in the neighbourhood of 1% for ordinary works of construction. If, however, the work is of a more dangerous nature a larger percentage might be quoted, but firm quotations can be obtained.

Approximate Cost of the Work in Pounds	*Percentage Addition to add to the Estimated Cost of the Work to allow for Small Plant and Tools*	
	Civil Engineering Works	*Building Works*
0– 5,000	1·25	2·00
5,000–10,000	1·00	1·60
10,000–15,000	0·75	1·25
over 15,000	0·50	0·80

In the case of National Insurance this is contributed weekly by both the employer and employee.

The payment by the employee is of no concern to the estimator since it is deducted from the man's wages, but the employer's contribution must be allowed for.

The amount payable by the employer depends upon the employee's age and the rates payable per week are laid down by the State.

The best method of allowing for insurances is by looking upon them as a Head Office charge in the case of those insurances covered by policies, and a General Site Charge in the case of National Insurance. They are then included in Establishment Charges and allowed for as a percentage addition made to the estimated cost of the Unit of Work.

The method of doing so, as shown, is simple and is sufficiently accurate for estimating purposes.

Allowing for Insurances covered by Policy, i.e. Workmen's Compensation, Employer's Liability, etc.

On most types of work the Labour Cost may be taken as approximately 50% of the Total Cost. Assuming that this is so and the rate quoted by the insurance company for the above insurances is 1% of the wages paid, then 50% of this or ½% may be added to the estimated cost of the Unit of Work to allow for these insurances, this ½% being included in the percentage addition made for Establishment Charges. This figure of 50% of the rate quoted may be used by the estimator to allow for these insurances as its degree of accuracy is sufficiently sound for estimating purposes.

Allowing for the Employer's contribution for National Insurance

The method of allowing for this is best illustrated by example:

Assuming the Employer's weekly contribution per man is ..	1/8
The man's rate of pay per hour is	1/6
The number of hours worked per week is	48
The Employer's contribution as a percentage of the man's earnings is	$\frac{1/8}{48 \times 1/6}$

= 2·30per cent.

Assuming as before that the Labour Cost is 50% of the Total Cost then 50% of this 2·30%, i.e. 1·15% may be taken as the percentage of the total cost to allow for the above insurances.

This insurance may, however, be allowed for in one of two ways.

1. By adding 1·15% to the estimated cost of the Unit of Work as already shown or
2. By increasing the actual Labour Rate, i.e. 1*s.* 6*d.* per hour, by 2·30% and using this rate in conjunction with the Labour Hours shown in the estimating tables.

Method 1 is the most simple to use and is sufficiently accurate for estimating purposes. The estimator would of course substitute in the example shown, the actual prevailing rates in calculating the percentage addition to make.

Percentage Allowance for Holidays with Pay Scheme

Under this scheme the employer contributes a fixed rate per man per week, and allowance for this can be made on exactly similar lines to that shown for National Insurance. State or Social Insurances may be allowed for in exactly the same way. The estimator, knowing the contributions which have to be paid by the employer, and the prevailing labour rates, can calculate the percentage addition to make.

Allowing for Cost of Water

The cost of water for the Works may have to be paid for in one of three ways:

1. It may be charged for as a lump sum by the water company, based on the value of the contract. In such a case its cost could best be allowed for by adding it as a lump sum plus a percentage to cover Establishment Charges and Profit.
2. It might be charged at so much per 1,000 gallons by the water company, the quantity used being measured through a meter. In such a case the estimator would have to assess the gallons required and compute its cost, allowing for it as a lump sum with a percentage addition added to allow for Establishment Charges and Profit.
3. The water itself might be free of cost, such as water taken from a spring or river, but the cost of pumping or hauling it to the site would have to be allowed for. In such a case it might either be allowed for as a lump sum or allowed for in the cost of the unit of work in which it is used, such as concreting, etc. Under the section devoted to "Concretor" an example of Water Cost is shown.

It is common practice to allow a figure of about 7*s.* 6*d.* per cent of the value of the contract for the cost of water and the estimator may use such a figure or compute one for himself by assessing the conditions appertaining to the contract being tendered for. Where water is available from the mains an allowance for this of about 7*s.* 6*d.* per centum of the contract value is reasonably accurate for estimating purposes.

Allowing for Watching, Lighting, and Traffic Control

Such items as Watching and Lighting, Control of Traffic by Flagmen, "Stop" and "Go" Boards, and Temporary Roads may have to be considered on some contracts but not on others. It is impractical to allow for these as a percentage of the cost and the best method of dealing with them is to assess their cost and then add a percentage to allow for Establishment Charges and Profit. The sum so arrived at may then be included in the tender either as a lump sum, or by increasing the Rates in the measured Bill to an amount sufficient to cover their cost.

The cost of Watching and Lighting, Traffic Control, etc., can be estimated by assessing the time for which they will be required on the contract.

Any other items specifically mentioned in the contract being tendered for which involve cost, such as a Contract Guarantee Bond for the due fulfilment of the contract, can be dealt with in the same way.

In estimating, the estimator has, first of all, to arrive at the cost of the unit of work, i.e. the plant labour and material cost. This is the cost as derived from the tables of plant and labour hour constants shown throughout this book under the various trades: bricklayer, carpenter, concretor, etc. Having arrived at this cost he then has to add to it a percentage to cover:

1. Head Office Charges.
2. General Site Charges on the site of the works itself.
3. The Net Profit.

This net profit can be looked upon as the contractors' own personal profit. In actual fact this percentage addition may be added as one flat percentage which allows for the three charges shown above. The method of making the percentage addition is shown in Section Four.

HEAD OFFICE CHARGES vary with different firms, depending to a great extent on turnover. The percentage to add to the estimated cost is worked out by the Head Office, they having available all the facts and figures as to Head Office administration costs, annual turnover, etc.; and as a round figure, should be about 5% of the cost of the works carried out.

GENERAL SITE CHARGES ON THE SITE OF THE WORKS are those charges in connection with the administration of the particular contract itself, and they also, as a round figure, should be about 5%.

Thus for Head Office and general site charges together, i.e. "overheads", a percentage addition of about 10% should be added to the estimated cost of the work.

THE NET PROFIT is variable and depends on the turnover. A large firm with large turnover might be content with a return of anything from 3% to 5%, whilst a smaller concern might require from 5% upwards. As a round figure 5% is considered a reasonable return.

Examples are shown of how Head Office and general site charges are arrived at and what percentage they are of the cost of work. The percentages shown are approximately what they should be, but vary according to the firm and size of the turnover.

Head Office Charges

These are made up of:

1. Salaries paid to staff at Head Office.
2. Rent, rates, taxes, light, power, heat, stationery, postage and telephones.
3. Depreciation of office contents, furniture, floor covering, etc.
4. Interest on capital, loans and bank charges.
5. Fire insurance and insurance of workmen under the National Insurance (Industrial Injuries) Act and Public Liability Insurance.

In the case of Head Office charges the percentage to add is worked out by the Head Office, they having available all the facts and figures as to Head Office administration costs, annual turnover, etc. This percentage varies with different firms but should be approximately, as a round figure, about 5% of the cost of the works.

Example of Head Office Charges

Head Office Charges per annum.		*Annual Cost of Works of Construction*
1. Staff salaries, directors' fees	£9,000	
2. Rent, rates, taxes, light, heat, power, stationery, postage, telephones	1,300	
3. Depreciation of office contents	200	
4. Interest on capital loans	1,500	
5. Insurances, fire and workmen's compensation	2,000	
6. Staff cars	1,000	
	£15,000	£300,000

∴ Percentage addition to add to the estimated cost of the work to allow for Head Office charges $\frac{15,000}{300,000} = 5\%$.

General Site Charges

These are made up of:

1. Salaries of agent, engineers, general foreman and administrative staff on the site itself.
2. Small plant and tool depreciation.
3. Consumable stores, postage, stationery and telephones.
4. Employer's contribution to National Insurance.
5. Employer's contribution to Holidays with Pay scheme.
6. Erecting and dismantling site offices, store sheds, etc., and haulage of same.

Example of General Site Charges

Assume that the contract to be tendered for consists of a concrete road with surface water drainage and that it has to be completed in six months.

The estimator has to consider the time element and also what staff will be required to carry out the work.

His make-up of the administration costs on the site of the works itself would probably be on the following lines:

General Site Charges. 6 months.		*Plant, Labour and Material Cost of the Contract*
1. Salaries of agent and site staff	£560	Estimated cost of the works .. £25,600
2. Allowance for small plant and tools	128	
3. Heat, light, power, stationery, and telephones on the site	40	
4. Allowance for National Insurance Contribution by employer	256	
5. Allowance for Holidays with Pay scheme	256	
6. Allowance to haul and erect site offices, cleaning offices, etc	40	
	£1,280	£25,600

∴ Percentage addition to add to the estimated cost of the work to allow for general site charges

$-\frac{1,280}{25,600} = 5\%$

From this will be seen that the estimator has to add to the estimated cost of the work, the following: 5% to allow for Head Office charges; 5% to allow for general site charges; a total of 10%. This is the percentage addition to add to cover "Establishment Charges".

The above disposes of those elements of the cost which are allowed for by making a percentage addition to the estimated cost of the Work or Unit of Work.

Establishment Charges

The only other percentage addition to be made is one to cover the net profit desired, and assuming this to be 5%, the total percentage addition the estimator would have to add to the estimated cost of the unit of work as arrived at from the tables shown throughout the book for estimating purposes, would be:

To allow for Establishment Charges ..	10%
To allow for net profit	5%
Total percentage addition ..	15%

This 15% is the gross profit, whilst 5% represents the net profit.

The method of making this percentage addition to the calculated cost of the various units of work as arrived at from the estimating tables in order to produce a tender for the work in question is shown in Section Four.

Allowing for the Payments made to the men for Time Lost due to Inclement Weather, the Guaranteed Minimum Week and the Holidays with Pay Scheme

In October 1945 it was agreed that men employed on the works in the building and civil engineering contracting industries should receive payment for time lost due to inclement weather at one half of the ordinary rate and a guaranteed minimum week of 32 hours at the ordinary rate for two weeks only.

The cost of such concessions being borne by the employer must also be allowed for in estimating. From recorded data the percentage addition averaged throughout the year, to allow for these concessions may be taken for estimating purposes as being 2·28% of the wages paid or 1·14% of the estimated cost of the work.

The Holidays with Pay Scheme may be allowed for in a manner similar to that shown for National Insurance as shown on pages 15 and 16, thus assuming the employer's contribution is 1/6 per man per week, the weekly hours worked 48, and the labour rate 1/6 per hour, the percentage addition to allow for this Holidays with Pay Scheme as a percentage of the man's earnings is $\frac{1/6}{48 \times 1/6} = 2{\cdot}08\%$ and as a percentage of the estimated cost 50% of this, i.e. 1·04%.

The total percentage addition to add to the Estimated Cost of the Work for Establishment Charges would then be on the following lines:

Head Office Charges.—(See page 17) say	5·00%
General Site Charges.	
Administrative charges (say 2·67%); allowance for small plant and tools (see page 15) (1·00%); insurances (see page 15) (1·15%); Holidays with Pay, employer's contribution (see above) (1·04%); payments made for time lost and the guaranteed minimum week (see above) (1·14%) ..	= 7·00%
∴ Total percentage addition to add for establishment charges	= 12·00%

This 12·00% is added to the estimated cost of the work or unit of work together with the percentage addition made for profit. For the method of making these percentage additions see page 29.

SECTION THREE

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COSTING THE WORKS OF CONSTRUCTION

The costing of the construction of the work is carried out for the various types of work such as trench excavation, pipe-laying, bulk excavation, concreting, bricklaying, etc., as shown itemised in the bill of quantities comprising the tender.

The object of this costing is three-fold:

1. To ascertain how the contract is progressing from a financial point of view.
2. To ascertain if money is being lost on any one item or items.
3. To obtain data of accurate progressive or average costs of various items of work which may be used for tendering purposes.

Regarding (1).—The engineer naturally wants to know if he is making or losing money.

Regarding (2).—It is imperative to know on which item or items money is being lost, or not made in sufficient amount. There is little point in completing a contract and then finding that money has been lost on it and then wondering where it *was lost*. If the work is costed week by week, in order to show "weekly costs" and "progressive costs" the contractor can immediately put his finger on the losing item and take steps to effect improvement. It is surprising how a losing item can be tackled by the enterprising and improved on. This is sometimes done by:

1. Cutting out labour and using plant.
2. Putting the work on to piece-work.
3. Paying the men bonus on output and so on.

The main thing is to *know* where the money is being lost, so that one can tackle the problem. Only costing will show this.

Regarding (3).—This is of great importance as sound tenders can only be produced from sound costs of similar work actually performed and it is the *fair average costs* which count in estimating.

The tendering constants shown in this book strike a fair average cost and can be used for estimating for all normal works of construction.

Methods of Costing the Works of Construction

There are various methods of costing the work and different firms adopt different methods, but whichever method is used it must:

1. Be accurate and produce as true costs as possible.
2. Be simple and speedy in operation, and not unduly costly.

Three methods of costing will be considered here, of which the writer has had experience.

Method 1.—In this method the plant and labour hours are carefully allocated to the various types of work constructed and the value of *the materials in such work is calculated* and a small percentage addition added to this material cost to cover loss and breakages.

Method 2.—This method is exactly the same as Method 1 with the exception that *the materials are carefully allocated and actually measured as used in the work.*

Method 3.—In this method only the actual plant and labour cost is considered as compared with what was allowed for in the tender make-up. This method shows how the job is costing from a plant and labour view, which is very useful for tendering purposes though this information is also obtainable from the other two methods.

All the above methods have their points and advantages.

Method 1 is the one which the writer personally prefers. The production of the costs is cheap, quick and involves no measurement of materials. It has been found in practice that the materials in the unit of work as calculated with a 2½% addition to cover loss and breakages work out remarkably accurately when checked at the end of a contract. This method gives good consistent costs when care is given to the plant and labour allocation.

Method 2 is also a good method but is more expensive than Method 1, as the question and the cost of allocating materials to the various plants and measuring them costs money. It should be observed that this measuring is quite apart from the usual checking of materials delivered to the site for the checking of quantity delivered.

Method 3 is the quickest of the three but only shows plant and labour costs which is not altogether satisfactory when wishing to arrive at what percentage the job is up or down as the value of the material does not enter into it. It is, however, useful for producing data for tendering purposes but as Methods 1 and 2 give both the plant and labour costs per unit and also the plant, labour and material cost per unit, which can be compared with the schedule rate tendered, they are the more satisfactory methods of costing to adopt.

The Data which has to be obtained in order to Cost Works

The following information is required in order that the works of construction may be costed. It is usual to cost it weekly although it may be done at longer intervals if desired.

Assuming that a weekly costing system is being carried out:

(1) The work has to be measured up by the engineer or surveyor under the various items of work, e.g. excavations, sewer excavations, lay and joint pipes, brickwork, concrete in roads, etc., etc.

(2) The plant hours have to be carefully allocated to the various items of work on which it was working. This is usually done by the foreman or ganger in charge.

(3) The labour hours have to be carefully allocated to the various items of work on which it was working. This is usually done by the foreman or ganger in charge.

(4) The materials used have to be either calculated per unit of work with an addition of 2½% to cover loss and breakages if Method 1 of costing is used, or be accurately allocated and measured if Method 2 is adopted.

The method of obtaining the above data is as shown below:

The Measurement of the Works

This is carried out by the engineer or surveyor and is entered up in a measurement book kept solely for this purpose. The various items of work are kept separated and are then abstracted and entered up on a measurement sheet so that the work done for that week, as well as the total quantity carried out to that date are available.

A typical works measurement sheet is as shown overleaf.

WORKS MEASUREMENT

Ganger: Smith *Week ending:* September 6th, 1943

Contract: LENDEN

Item	*Description*	*Unit*	*Weeks Quantity*	*Previous Quantity*	*Quantity to Date*
1	Bulk excavation..	C. Yds.	1,000	2,000	3,000
2	Excavate trench for 9 in. sewer average depth 6 ft...	L. Yds.	80	120	200
3	Lay 9 in. concrete tubes	,,	60	110	170
	etc., etc.				

Plant and Labour Allocation

This consists of allocating the hours of plant and labour to the various items of work carried out. It will be appreciated that great care and accuracy must be exercised in allocating these hours to the various items of work, if accurate costs are to be obtained.

The system of allocating these hours must be both simple and quick, as it is necessarily carried out by the foreman or ganger in charge of the construction of the work. To this end, it is always advisable to have a daily allocation sheet for plant and labour, these being entered up at the end of each day's work. These sheets can then be summarised at the end of the working week on a weekly plant and labour hours allocation sheet.

A typical Allocation Sheet for plant and labour is shown at the foot of this page.

Every help should be given by the engineer in charge of the construction to the foreman or ganger in his allocation, to ensure that it is a true return of the hours against the corresponding item of work.

TYPICAL ALLOCATION SHEETS FOR PLANT AND LABOUR

Note.—The weekly allocation sheet is similar to the daily, but headed "Plant and Labour Hours Weekly Allocation Sheet".

PLANT AND LABOUR HOURS DAILY ALLOCATION SHEET

Ganger: Smith *Date:* 6th September, 1943

Contract: LENDEN

Item	*Description*	*Labour*				*Plant*			
		Labourer hrs.	*Brick-layer hrs.*	*Pipe-layer hrs.*	*Jointer hrs.*	¼ *cu. yd. Mech. Excav. hrs.*	7/5 *Con. Mixer hrs.*	4/5 *Ton Lorries hrs.*	*Steam Roller hrs.*
1	Excavate trench average depth 6 ft.	80	—	—	—	9	—	—	—
2	Lay and joint 9 in. stoneware pipes ..	24	—	8	8	—	—	—	—
3	Concrete bed and haunch to pipes ..	40	—	—	—	—	8	—	—
		etc.		etc.					

Note.—The ganger and leading hands' time and tea-boy (if any), is allocated throughout the various items in proportion at the end of each week by the engineer, so that the cost, including them, is obtained.

It should be impressed on the ganger who allocates the hours that he ***must*** allocate all time to the items of work and not to irrelevant items, as the tendency is to allocate time to such things as unloading pipes, etc., thinking that by so doing the cost of the actual pipe-laying is being kept down, whilst, in actual fact this unloading time is part and parcel of the pipe-laying and should be allocated under such.

Description of Items

It is advisable for the engineer to fill in on the daily allocation sheet the description of the various items as shown, as this is a guide to the ganger and ensures his allocating to the relevant items.

There are, of course, on every contract, additional works and dayworks and a separate note of these should be kept.

Dayworks and Additional Works

On almost all works of construction work is done which was not included in the original contract as there are usually alterations, etc., carried out. These extra works come under two headings: Dayworks, and Additional Works.

1. DAYWORKS

In the case of daywork, the work is constructed and a careful note made of its cost. This is done by recording all the plant and labour hours and the materials used in its construction. Under the terms of the original contract the contractor has usually agreed that he be paid for all dayworks, their actual cost plus a percentage addition to allow of his making a profit on it. He therefore cannot lose on any dayworks carried out, as his profit is assured. It is essential, therefore, that proper daywork records of any work so carried out be kept, and that they be signed and agreed as to their correctness by the client for whom the work is undertaken. No dispute can then be raised on completion of the contract when the final account is rendered.

DAYWORK SHEET No. 1

Ganger: Smith *Date:* 6th September, 1943

Contract: LENDEN

Description	*Lab. hrs.*	*Rate*	£	*s.*	*d.*	*Materials*	*Rate*	£	*s.*	*d.*

2. ADDITIONAL WORKS

Regarding additional works, it is often the case that no rate for the class of work constructed under this heading appears in the priced bill of quantities comprising the accepted tender, and rates for this work have to be agreed on its completion.

This additional work cost should also be carefully recorded as for dayworks, as the engineer is then in the happy position of knowing what it costs when he comes to agreeing rates for it and has a target at which to aim so as to make sure of a profit. A typical daywork sheet is shown above; additional works can be allocated on the same sheet, but headed "Additional Works".

The Materials—The Cost per Unit of Work

These are dealt with in a different manner in Methods 1 and 2 as shown.

Method 1.—In this case the cost of the material per unit is calculated whether it be cu. yds. of concrete, brickwork or anything else, and 2½% to this cost is added to allow for loss and breakages.

Under each respective section, tables are shown giving all data necessary for computing this calculated cost of material, such as various concrete mixes under "Concretor", brickwork under "Bricklayer", and so on.

Method 2.—In this case the actual quantities of materials as used, are measured.

Example.—If concreting with 6 to 1 ballast concrete over a period of one week, the materials for the week would be noted as shown on the material weekly allocation sheet shown below.

MATERIALS

Ganger: Smith *Weekly Allocation.* *Week ending:* 6th September 1943

Plant 14/10 Concrete Mixer No. 7

Contract: LENDEN

Date	*Ballast—cu. yds.*			*Cement—tons*		
	Already on site	*Delivered site during week*	*Not used*	*Already on site*	*Delivered site during week*	*Not used*
31st August ..	10	—	—	2	—	—
1st September..	—	120	—	—	20	—
3rd September	—	100	—	—	20	—
6th September	—	—	30	—	—	8
Total ..	10	220	30	2	40	8

∴ Ballast used for week $= (10+220) - 30 = 200$ cu. yds.

Cement used for week $= (40 + 2) - 8 = 34$ tons.

It will be noted that: (1) The material lying on the site has to be measured at the end of each week; (2) the material delivered to the site during the week has to be recorded.

All the data have now been obtained to enable the work to be costed and this is done as shown in the following Methods of Costing.

Method No. 1 of Costing the Work

1. The weekly allocation of hours for plant and labour are monied out under the various items of work.
2. The cost of the material per unit is worked out and 2½% added to allow for loss and breakage.
3. The weekly quantity of work carried out is worked out by the engineer.
4. The week's all-in cost of plant and labour for each item of work is divided by the corresponding quantity of work done under that item and this gives the plant and labour actual cost of the work per unit for that item of the work.

   The calculated material cost per unit added to the plant and labour cost per unit gives the total cost per unit.

Example.—Showing the method of working out the cost per unit.

Assume 200 cu. yds. of 6 to 1 ballast concrete placed in the work for the week.
Ballast cost 10/- cu. yd. Cement cost 60/- ton.

ACTUAL PLANT AND LABOUR COST.—The plant working costs per hour are usually supplied by head office, and the method of computing these can be seen under Section Twenty.

Assuming the labour cost allocated for the week = £25 4 0
Assuming the plant cost allocated for the week = £44 16 0

Total £70 0 0

Then 200 cu. yds. cost £70.

$\therefore$ 1 cu. yd. actually costs $\frac{£70}{200} = 7/-$.

$\therefore$ The plant and labour actual cost = 7/- per cu. yd.

CALCULATED MATERIAL COST.—From the tables showing concrete mixes under the section devoted to "Concretor".

6 to 1 ballast concrete requires per cu. yd. of concrete:

1·26 cu. yds. ballast at 10/- .. .. .. = 12/7
0·22 tons cement at 60/- .. .. .. = 13/2

25/9
Add 2½% to allow for waste .. .. .. = -/7

Calculated material cost per cu. yd. .. .. = 26/4 cu. yd.

Total actual cost per cu. yd. of 6-to-1 ballast concrete placed in the work is:

Plant and labour cost per cu. yd. .. .. = 7/-
Material cost per cu. yd. .. .. .. = 26/4

Total cost per cu. yd. .. .. = 33/4

Assuming the tendered rate of this concrete is 38/4 per cu. yd.
The gross profit is then 38/4 − 33/4 = 5/- per cu. yd.

and the percentage gross profit is = $\frac{5/-}{\text{cost}} = \frac{5/-}{33/4} = 15\%$ based on the cost.

Method No. 2 of Costing the Work

So far as the plant and labour cost per unit is concerned this is carried out exactly as set out for Method No. 1, but the material cost is arrived at from the actual measurement of the material as used in the work. The method of arriving at this quantity of material was shown earlier in this section.

Example.—Showing the method of computing the cost per unit, assuming:

195 cu. yds. of concrete was placed in the work for the week as measured.
250 cu. yds. of ballast at 10/- cu. yd. was used as measured during the week.
44 tons cement at 60/- ton was used as measured during the week.
The material cost then becomes per cu. yd.:

250 cu. yds. ballast at 10/- .. .. = £125 0 0
44 tons cement at 60/- .. .. .. = 132 0 0

$\therefore$ Total cost of 195 cu. yds. concrete .. .. .. = £257 0 0

$\therefore$ 1 cu. yd. concrete = $\frac{£257}{195}$ = 26/4 per cu. yd.

If the plant and labour cost = 7/- per cu. yd. (as shown under Method 1), then the total actual cost per cu. yd. of concrete placed in the work is:

Plant and labour cost	=	7/-
Material cost	=	26/4
Total cost per cu. yd.	=	33/4

Assuming the tendered rate for this concrete is 38/4 per cu. yd.:

The gross profit is 38/4 − 33/4 = 5/-, and the percentage gross profit is $\frac{5/-}{\text{cost}} = \frac{5/-}{33/4}$

= 15% based on the cost.

Method No. 3 of Costing the Work

In this method only plant and labour costs are obtained, the materials being ignored. This is quite satisfactory so far as producing plant and labour costs for future reference are concerned, but is not much use for checking what gross percentage profit is being made on the work, as materials are not taken into account. Method No. 1 is a far more satisfactory one and only involves the calculating of the material per unit, a simple matter, which can be done in the office.

The method for producing the plant and labour costs under this method (No. 3) is similar to that shown for Methods No. 1 and 2.

The Weekly Cost Sheet

Having seen how to work out the costs, cost sheets are prepared and the typical sheet shown is usually adopted as it shows not only the week's costs but also the progressive average costs. These latter are the ones that matter as they are the true average costs.

Costs may be done at weekly or longer intervals but it is good policy to produce them at not greater than fortnightly intervals as the job and its progress can then be carefully watched, as can also its financial position.

In the typical cost sheet shown the columns have been numbered 1 to 16 to simplify its explanation. The following is the way to work out the costs, the numbers representing the number of the columns.

To complete the Cost Sheet

Week's plant and labour cost per unit	Column	7 ÷ 4
Week's plant, labour and material cost per unit	,,	10 + 9
Progressive plant and labour cost per unit	,,	8 ÷ 6
Progressive plant, labour and material cost per unit ..	,,	11 + 9
Total cost of the work constructed	,,	6 × 13
Total value of the work constructed	,,	6 × 14
Gross profit made on the contract to date	,,	(16 − 15) ÷ 15 taken from the total column when added

Note.—This profit arrived at represents the *gross profit* made on the contract. Calculate the *net profit* as the work proceeds, using the cost sheets, as follows:

1. TO CALCULATE THE NET PROFIT AS THE WORK PROCEEDS

Assuming that the value of work constructed at 6th September was		£10,000
Actual cost of the work at that date was		8,700
Allow for Head Office charges 5% of £8,700	=	435
Allow for general site charges 5% of £8,700	=	435
	Total	£870

Typical Cost Sheet

Cost Sheet No.......

Ganger......................

Week ending............

Contract: Gednol

1	2	3	4	5	6	7						8						9	10		11		12	13	14	15			16		
Item No.	*Description*	*Unit*	*Week's Quantity*	*Previous Quantity*	*Total Quantity*	*Week's Cost as Allocated*						*Progressive Cost as Allocated*						*Material Cost per Unit*	*Weekly Cost per Unit*		*Progressive Cost per Unit*		*Week's Total Cost per Unit Plant, Labour and Material*	*Progressive Total Cost per Unit Plant, Labour and Material*	*Rate Tendered*	*Total Progressive Cost of Work to Date*			*Value of Work Done as Tendered to Date*		
						Plant			*Labour*			*Plant*			*Labour*				*Plant*	*Labour*	*Plant*	*Labour*									
						£	*s.*	*d.*	£	*s.*	*d.*	£	*s*	*d.*	£	*s.*	*d.*									£	*s.*	*d.*	£	*s.*	*d.*
1	Bulk Excavation	C.70	1000	2000	3000	112	6	8	16	13	4	325	0	0	50	0	0	Nil	2/3	4d.	2/2	4d.	2/7	2/6	3/-	375	0	0	450	0	0
2	Concreting Foundations etc., etc.	C.70	100	200	300	25	16	6	9	3	4	67	10	0	30	0	0	25/-	5/2	1/10	4/6	2/-	32/-	31/6	36/-	472	10	0	540	0	0
																							TOTAL			847	10	0	990	0	0

$$\therefore \text{Gross profit} = \frac{£990 - £847\ 10\ 0}{£847\ 10\ 0} = 16\tfrac{3}{4}\%\ \text{based on cost}$$

Note.—In connection with this Cost Sheet, the weekly and progressive plant and labour cost may be calculated thus:

Weekly Plant Cost per Unit = Weekly Plant Cost Column 7 divided by Week's Quantity Column 4

Weekly Labour Cost per Unit = Weekly Labour Cost Column 7 divided by Week's Quantity Column 4

Progressive Plant Cost per Unit = Progressive Plant Cost Column 8 divided by Progressive Quantity Column 6

Progressive Labour Cost per Unit = Progressive Labour Cost Column 8 divided by Progressive Quantity Column 6

∴ Value of works constructed less these two charges =	£10,000
Less	870
	£9,130
Actual cost of the work	£8,700
∴ Net profit	£430

Percentage net profit $= \frac{£430}{\text{cost}} = \frac{430}{8{,}700}$.

∴ Net profit = 5% based on the cost.

This 5% may be looked upon as the contractor's own personal profit.

2. To Calculate the Net Profit when the Work is Wholly Completed

The position in this case is rather different for this reason: the total cost of the work is now known, including all the *actual general site charges.*

The allowance for Head Office charges remains the same, viz. 5% of the cost.

Assuming the value of the completed work is	£50,000
Total cost of the works of construction including all general site expenses is	45,400
Allow for Head Office charges: 5% of the cost, i.e. 5% of £45,400 = £2,270	
∴ Value of work constructed less Head Office charges =	£50,000
Less	2,270
	£47,730
Actual cost of works including general site expenses	£45,400
∴ Net profit =	£2,230

Percentage net profit $= \frac{£2{,}230}{\text{cost}} = \frac{2{,}230}{45{,}400}$ ∴ Net profit = 5% based on the cost.

Note.—In certain cases the estimator may find in pricing a "Bill of Quantities" that a certain amount of latitude has been taken by those responsible for the preparation of the "Measured Bill" in that the unit measurements "billed" may not be in accordance with the "Standard Method of Measurement". In this book the data shown from which to estimate the cost of supplying and fixing timber floor joists are in accordance with the "Standard Method of Measurement", i.e. it is related to the cost *per cubic foot,* but this item might actually appear in the bill in terms of *per lineal foot.*

In "building up" the cost of this item from the data shown, the estimated cost per cubic foot must first be computed and then reduced to terms of per lineal foot for the size of joist in question.

e.g. If the cost of supplying and fixing a 6 × 2 in. timber floor joist as estimated from the data shown for estimating purposes in this book is 10/- per cubic foot, the estimated cost per lineal foot is then:

$$\frac{6 \times 2 \times 12\text{ in.}}{12 \times 12 \times 12\text{ in.}} \times 10/-$$

$$= 10d.\ \text{per lineal foot.}$$

SECTION FOUR

★

HOW TO TENDER

Tendering consists of estimating the cost of various items of work and adding thereto a percentage addition of sufficient amount to allow for profit. Particular care must be taken by the estimator to see that no element of the cost is omitted.

Elements which Constitute the Cost

The Cost consists of:

1. The Plant Cost.
2. The Labour Cost.
3. The Material Cost, a small allowance being made for bulkage and waste as shown in the Estimating Tables.
4. Establishment Charges embodying all costs in connection with:
    - (*a*) Head Office Charges.
    - (*b*) General Site Charges.
5. The cost of Water for the Works.
6. The cost of Watching and Lighting the Works if required.
7. The cost of Controlling Traffic by "Stop" and "Go" boards, etc., if required.
8. The cost of Temporary Roads if required.
9. The cost of a Guarantee Bond if required for the due fulfilment of the contract.
10. Any other specific items involving cost which may be embodied in the contract being tendered for.

Items 1, 2 *and* 3.—Are calculated from the data shown in the estimating tables.

Item 4.—This is allowed for by making a percentage addition to the Estimated Plant, Labour and Material cost of the Unit of Work as arrived at from the estimating tables. (See Section Two.)

Item 5.—This may either be allowed for as a lump sum, as a percentage of the value of the work or by including its cost under the Plant, Labour and Material Cost as computed from the estimating tables. (See Section Two.)

Items 6, 7, 8, 9 *and* 10.—Can be allowed for individually or collectively if required on the contract being tendered for, either as lump sums or by increasing the Rates in the measured Bill. The amount should be sufficient to cover their cost plus a percentage to allow for Establishment Charges and Profit. (See Section Two.)

The profit is allowed for by making a percentage addition to the Total Cost.

The Method of Making the Percentage Addition to the Estimated Plant, Labour, and Material Cost of the Work in order to compute the Rate to Tender

It must be carefully noted that:

(1) The plant and labour hour constants shown in the tables throughout the various sections when extended by the prevailing plant hire and labour rates applicable to the contract being tendered for, give the *cost of that unit of work* and NOT the tender rate.

(2) To this cost is added a percentage sufficient to allow for "Establishment Charges" and "Profit" and this is usually done in one of two ways:

Method 1

This is the method the writer personally adopts as it is quick and ensures a flat gross profit on the "make-up" as a whole, irrespective of the value of the material in the item.

This method is carried out by adding a flat percentage to the estimated cost of the work as calculated from the tables.

Example.—Suppose the item in the tender to be priced is:

Mix and place 6 to 1 concrete in carriageways per sq. yd., and

Ballast costs	10/- cu. yd.
Cement costs	60/- ton
Labour rate is	1/6 per hour
14/10 mixer and driver rate	6/- per hour
Dumper and driver rate	8/6 per hour

The problem is to calculate the tender rate to make, say 15% gross profit; *this 15% being made up as follows*:

1. Head Office charges	5%
2. General site charges	5%
3. Net profit	5%
Total	15%

We will assume that the estimator has decided to use a 14/10 concrete mixer and to transport the concrete by dumper from the mixer to where it is placed: a haul of 220 yds., the mixer being loaded by hand.

Material Cost of 6 *to* 1 *Ballast Concrete* (*from tables*) *per cu. yd.*

	1·26 cu. yds. ballast at 10/- per cu. yd.	=	12/7
	0·22 tons cement at 60/- per ton	=	13/2
			25/9
From Tables	Labour .. 1·80 hours at 1/6	=	2/9
	14/10 concrete mixer and driver .. 0·2 hours at 6/-	=	1/3
	Dumpers and drivers .. 0·26 hours at 8/6	=	2/5
	∴ Total plant labour and material cost	=	32/2 cu. yd.
	Add 15%	=	4/9
	∴ Tender rate	=	36/11 cu. yd.

Note.—Total Dumper hours per cu. yd. = 0·06 hours travelling time per cu. yd.
= 0·20 hours while it stands having 1 cu. yd. loaded into it.
Total = 0·26 hours.

Note.—The foregoing method is very quick and simple but is not strictly accurate in that it does not correctly allow for the percentage profit on the *gross.* To allow for this correctly the percentage additions should be added in two operations thus:

Total Plant, Labour and Material Cost ..	=	32/2 cu. yd.
Add for Establishment Charges 10% ..	=	3/2
		35/4
Add for Profit (5%)	=	1/9
∴ Tender Rate	=	37/1

By using this method the correct percentage profit on the gross is obtained, but it might be noted that the percentage difference between this alternative method and Method 1 is very small.

The estimator may, however, use this alternative method if he prefers it.

Method 2

This method is carried out by:

1. Adding a percentage to the plant and labour cost per unit approximately 33⅓%.
2. Adding a percentage to the material cost per unit, approximately 10%.

Example.—Using the same example, viz.: 6 to 1 concrete as shown in Method 1, this system of work-out then becomes:

Material.—Material cost of 1 cu. yd. 6 to 1 concrete	.. ..	=	25/9 cu. yd.
	Add 10%	=	2/7
		=	28/4 cu. yd.

Plant and Labour

Labour	1·80 hours at 1/6 ..	=	2/9
14/10 concrete mixer and driver	0·2 hours at 6/- ..	=	1/3
Dumper and driver	0·26 hours at 8/6 ..	=	2/5
			6/5
	Add 33⅓%	=	2/3
	Total	=	8/8 cu. yd.

∴ Tender rate = Material ..		28/4
Plant and Labour		8/8
Tender rate	=	37/0 cu. yd.

This method is more tedious and the work-out takes longer.

In the case of tendering for Works where no material is involved, i.e. Plant and Labour, or Labour Only Contracts, it is usual to adopt Method No. 1 adding a flat percentage to allow for profit.

In the case of those Elements of the Cost which are allowed for on a "Lump Sum" basis, the percentage additions to allow for Establishment Charges and Profit are added to their estimated cost in a manner similar to that shown.

SECTION FIVE

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HOW TO USE THE TABLES FOR ESTIMATING

The tables shown throughout this book under the various trades show the hours taken by plant and labour to produce one unit of the work as itemised in the bill of quantities comprising the tender.

This means that they give *the cost of the unit of that work* and NOT *the rate to tender.*

To compute the rate to tender an amount has to be added to the cost to cover:

1. Head Office charges.
2. General site charges.
3. The net profit.

This is added as a percentage of the cost (see previous section).

Method of using Tables to get the Cost

THE PLANT COST.—The cost of the plant per unit is obtained by multiplying the plant hour constant shown in the tables by the working cost of the plant per hour. This working cost covers:

1. Machine hire per hour allowing for depreciation, repairs and renewals.
2. Drivers' wages per hour.
3. Fuel, oil, grease consumed per hour.
4. Insurance and Licences Cost per working hour.

These plant working costs (or hire rates) per hour and the method of arriving at them are shown in detail under Section Twenty.

THE LABOUR COST.—This is obtained by multiplying the labour hour constant shown in the tables by the labour (or tradesmen's) rate which will have to be paid on the contract that is being tendered for.

THE MATERIAL COST.—The material cost per unit is obtained by *calculating the materials per unit*, whether the material be concrete, brickwork, hardcore, tarmac, or anything else.

Under the various sections showing the "trades", are shown the materials required per unit, such as aggregate, sand, and cement, required for various concrete mixes, tons of tarmac required per sq. yd. of various finished thicknesses, and so on.

Having calculated the quantity of material required per unit this is multiplied by the rate which has to be paid for it, and the cost of the material per unit is the result.

THE COST PER UNIT OF THE WORK is then the sum of these three: plant cost; labour cost; material cost.

If there are no materials present in the unit, but only labour, or plant and labour, the cost is arrived at as shown and the percentage addition added in the same way.

Note.—The labour hour constants shown under the various sections allow for all off-loading from lorries and laying complete in the work and assume that the materials are delivered "on the site" adjacent to where they are to be placed in the work. Any cost involved in double handling or hauling the materials, such as from a station, if borne by the contractor must be taken into account in assessing the actual cost of the material delivered "on the site".

The following example shows how to compute the cost and the rate to tender per unit when no material is involved.

Example.—Find the cost and thus the rate to tender per cu. yd. if a gross profit of 15% has to be made to excavate a trench in dry ground by mechanical excavator using a ¼ cu. yd. backacter machine. The trench has to be dug 6 ft. deep and refilled. Wanted the price per cu. yd. to tender for the excavation apart from the timbering.

Assuming the labour rate is 1/6 per hour and the working cost of the ¼ cu. yd. backacter machine is 8/6 per hour.

The 15% gross profit covers the Head Office charges, general site charges, and also the net profit.

Plant and Labour Cost per cu. yd.

From Tables: Excavate dry trenches at 6 ft. deep.

Labourer	2·37 hours at 1/6 ..	=	42·66 pence.
Backacter machine	0·12 hours at 8/6 ..	=	12·00 ,,
	∴ Cost per cu. yd. ..	=	54·66 ,,
	Add 15% ..	=	8·00 ,,
	∴ Tender rate ..	=	62·66 ,,

Say, 5/3 per cu. yd.

Note.—Timbering cost not included in the above (see Table, p. 176).

Example.—To show how to compute the cost and the rate to tender per unit when there is material involved.

Find the cost and thus the rate to tender per cu. yd. if a gross profit of 15% has to be made, to supply, mix and place 6 to 1 mix concrete in a 12 in. wall, using a 10/7 concrete mixer and the concrete barrowed to position, when:

Ballast costs	10/- cu. yd.
Cement costs	60/- ton
Labour rate	1/6 per hour.
10/7 Concrete Mixer and driver ..	5/2 ,,

Material Cost per cu. yd.

From table of various mixes of concrete shown in the Concretor Section.

6 to 1 concrete per cu. yd.

Ballast ..	1·26 cu. yds. at 10/-	=	12/7
Cement ..	0·22 tons at 60/-	=	13/2
∴ Cost of material per cu. yd.		=	25/9

Plant and Labour from Table per cu. yd.
(Concretor section)

Total Labour hours ..	4·94 hours at 1/6	=	7/5
10/7 mixer, hire per hour..	0·48 hours at 5/2	=	2/6
∴ Cost per cu. yd. ..	.. .. ..	=	35/8
Add 15% gross ..	.. .. ..	=	5/4
∴ Tender rate	.. ..	=	41/0 cu. yd.

Note (from Tables) labour hours is made up of:

Mixing and placing only ..	3·84 hours per cu. yd.
Barrowing	1·10 „ „
Total ..	4·94

Points of Importance in connection with using the Estimating Tables

Several points of importance must be observed carefully when using the tables, and these are set out below. The estimator must use care to ensure that nothing is missed out of his estimated cost of the unit of work.

1. The cost arrived at from the plant and labour hours per unit as shown in the tables *is* the cost of that unit of work and *not* a rate to tender.
2. To the above cost per unit has to be added a percentage of sufficient amount to allow for all Head Office and General Site Charges and net profit (see Sections Two and Four).
3. In using the tables care must be taken that no part or parts of the operations (as tabulated in the estimating tables for the unit of work) is missed out, e.g.:
   (*a*) Concreting to various works is shown under more than one table. The main table is devoted to "Mixing and Placing in the Work Only", while transporting, hoisting etc., are shown under subsequent tables.
   (*b*) Bricklaying is shown under "Lay Bricks Only" tables, while the pointing is shown under a separate table.
   (*c*) Excavation is shown as "Excavate and Load Only" under one table, while the transporting of it to tip, hoisting, etc., is shown under subsequent tables.

   In such cases, therefore, more than one table has to be used to compute the cost of the unit of work and the estimate of the cost thus built up.
4. No part of the work involved in constructing the unit of work must be omitted unless it is billed separately in the bill of quantities, e.g.:

   In concreting roads the "Mixing and Placing Only" tables allow for tamping the concrete but *not* for curing it or bullnosing the edges, or placing the side screeds. The cost of these latter items must be included under the cost of the unit of work. If separately billed in the bill of quantities they will be priced under those items, but if they are not their cost must be lumped in with the main item.
5. The hour constants shown for estimating purposes assume materials are delivered to site by lorry and allow for all off-loading from lorries and laying in the work complete.

6. The Cost of such items as Watching and Lighting, Control of Traffic by Flagging or "Stop" and "Go" Boards, Temporary Roads, Contract Guarantee Bond, etc., must be allowed for in the Tender if required, on the Contract being tendered for. The method of allowing for these is shown in Section Two. They are not allowed for in the Percentage Addition made to the Estimated Cost of the Unit of Work for Establishment Charges.

Note.—The notes embodied under the trade sections draw attention to the above points where necessary and clearly advise the estimator on how to cost the unit of work.

The Multipliers

Multipliers are shown for use with the plant and labour hour constants shown in the estimating tables and also for plant outputs in various classes of ground, varying depths, etc.

They form a simple and direct way of keeping the data under the sections concise and make it possible to give much information in little space.

Example.—Stock brickwork is tabulated for brickwork in lime mortar. By means of the multiplier given, viz.: 1·25, the cost of the brickwork in cement mortar, can be found simply by multiplying its cost in lime mortar by 1·25. Similarly, machine outputs can be found for various classes of ground by using the multipliers shown, as can various types of work carried out under the various sections. The multiplier tables are clearly set out and no difficulty should be experienced by the estimator in their use.

SECTION SIX

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THE SITE ADMINISTRATIVE STAFF

The staff required on the site consists of:

1. THE AGENT who is in sole charge and is responsible for the works, its quality, speed of construction and cost, as well as all staff organisation.
2. THE ASSISTANT AGENT, assistant to the above co-ordinating the work of the engineers.
3. THE ENGINEERS, who are responsible for:
   (*a*) All the setting out and levelling of the work.
   (*b*) The administration of the works on the site in conjunction with their foremen. In cases where no surveyor is appointed the engineers are also responsible for the measuring up of the work, the preparation of accounts and the costing of the works.
4. THE SURVEYORS, who are responsible for the whole of the measuring of the work and the preparation of the accounts.
5. MATERIAL CLERKS AND CHECKERS, responsible for all materials delivered and the ensurance that the correct quantities are delivered as stated on the delivery tickets and as accounted for payment.
6. PAY CLERKS responsible for all the wages paid.
7. COSTING CLERKS.—The costing on a small contract is usually done by one of the engineers, but on really large works costing clerks are employed who are responsible for all costing of works.
8. TIMEKEEPERS, who are responsible for recording the hours worked by all wage-earners on the site, and for checking that these hours are actually worked by them.

General Clerks, Typists, Telephone Attendants and Office Cleaners to keep the site offices clean, will also be required.

The Quality of the Staff

It is of the utmost importance to have thoroughly experienced staff in all branches of the site administration. A highly experienced "go-ahead" agent surrounds himself with efficient staff and this is one of the essentials to produce:

1. Sound work of first-class quality.
2. Work constructed at a fast rate of progress.
3. Work produced at low competitive cost.

It is a fact that well paid competent staff will construct excellent work efficiently whilst lower salaried but less competent staff will lose money on its construction and produce less sound work at the same time. First-class staff pay handsome dividends both in quality of work and its cost. It is the blending of the whole which ensures sweet running with consequent satisfactory results.

The Agent should be thoroughly experienced in the class of work of which he is to take charge, a good organiser, and a good handler of staff and men.

The Engineers should be thoroughly reliable and good instrument men, i.e. thoroughly conversant with the level and theodolite, as errors in this connection can be most costly.

The Engineer or Surveyor who measures up the work and prepares the account is of great importance. He should be of pleasing personality, a good mixer, and have a knowledge of mathematics. Some men have a flair for this sort of thing and miss nothing in the way of measurement which so affects the financial position of the contract.

Material Checkers and Timekeepers should be men of good type, honest and straight dealing, who will see to it that the contractor gets a correct statement of affairs as regards the quality and quantity of the materials delivered to the works and the hours of labour expended upon it

The Amount of Staff Required (see p. 42)

The number of staff required on a contract depends on:

1. The size of the contract.
2. The type of the contract.
3. The time allowed for the construction of the works.

It will be appreciated that the cost of the site staff or general site charges must bear a reasonable proportion to the cost of the work.

The estimator, when preparing the tender, allows for the general site charges as a percentage of the cost of the works. It is therefore of importance that the staff on the actual work should be such that its cost does not exceed this.

Some types of contract require more supervision than do others: again, if a large quantity of work has to be constructed in a short time this necessitates a large amount of labour on the work with the consequent sufficiency of staff to administer it.

The agent in charge must therefore see to it that he has just the right quantity and combination of staff on the work to ensure that:

1. The work is run and organised efficiently.
2. The work is constructed at low competitive cost.
3. The work is constructed in the contract time.
4. The staff costs are a reasonable amount of the cost of the work executed.

General site charges should not cost more than 5% of the cost of the work executed, although this figure is given as a guide and may vary a percentage or so either way.

For a detailed work-out of the staff required for a particular contract—see Section Seven.

The agent's endeavour, therefore, so far as his staff are concerned, must be to see:

1. That the number of staff employed is as low as possible without sacrificing efficiency and output of work.

2. That the quality and capabilities of his staff in all branches of the work are of a high order.
3. That every member pulls his weight and is kept actively employed.
4. That the whole combination of staff is sufficient to administer the construction of the work in the time allowed.
5. That the cost of the supervision is reasonable and does not exceed that percentage of the cost of the work which was allowed for in the tender make-up.

With regard to (5): it is a good policy for Head Office to inform the agent what percentage of the cost of the work *was* allowed for his general site charges, as he then has a target which he knows he must not exceed. A good agent strives to work below this percentage allowance, if at all possible, as any saving effected on the site administration all goes to help towards any profit which may be made. The usual procedure, however, is for Head Office to tell the agent in charge the gross profit he must make on the work.

SECTION SEVEN

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ORGANISING THE WORK

Points of importance in organisation, for the agent in charge, showing how to:

1. Compile programme for carrying out the works.
2. Build up the office administrative staff, engineers, surveyors, clerks, etc.
3. Build up the labour administrative staff, foremen, gangers, leading hands, etc.
4. Assess the plant required.
5. Assess the labour required.
6. Assess the materials required.
7. Produce progress charts and check output.

The co-ordination and balance of the whole of the above is absolutely necessary if the works of construction are to progress smoothly and efficiently at a fast rate of progress, at low competitive cost, and be completed in the time allowed.

Organising the Works—Duties of the Agent

The agent, having been appointed to take charge of the construction of the work, has in his possession, the following, before he commences the work:

1. The plans of the work and all its details.
2. The priced bill of quantities which comprises the tender so that he knows what rate he has got for all the various items of work incorporated in the tender.
3. The date on which the works of construction have to be completed.
4. The gross profit on the job which he is expected to make, having been told this by the Head Office.

His problems then become, and these he must settle first of all before commencing operations:

1. How he will carry out the work, in what sequence he will start the various operations, and when.
2. What type and number of office administrative staff he will require to construct the works in the time allowed.
3. What plant, both type and quantity he will require to construct the works in the time allowed.
4. What labour and labour supervision he will require to construct the works in the time allowed.
5. What materials he will require to construct the works in the time allowed.

Programme of the Works

This is drawn up by the agent when arrangements are made that the various items of work which have to be constructed shall be started on a certain date and in certain sequence, and plant, labour and materials then arranged for, in order that the work shall be completed in its entirety in the time allowed. This programme must be carefully balanced to ensure that the work shall progress smoothly to completion.

This programme is, of course, different for every type of contract and it is not possible to show in a book a programme for every type of job as this would involve thousands of combinations and run to many volumes. In order to demonstrate how this programme of works is evolved, a typical example is shown. Every endeavour should be made to complete the work as well inside the contract time allowed as possible, by using plant of good quality and to sufficient amount.

Example.—It will be assumed that the contract in question is as set out below, it being for the construction of a new concrete road in the carriageway of which is laid a 9 in. surface water sewer. The time allowed for the completion of the work is five months.

The following are particulars of the contract:

1. Value of the tender, £30,000.
2. Total volume of bulk excavation over the site of the road to be excavated 8,000 cu. yds.
3. Total 9 in. surface water sewer to be laid 3,000 L. yds.
4. Total gulley pots and their connections to be laid 100 No.
5. Total area of 6 in. concrete carriageway to be laid 24,000 S. yds.
6. Total length of the new carriageway is 3,000 L. yds. by 8 yds. wide.

The Order of Procedure

It is apparent that before the carriageway can be laid, the bulk excavation and the 9 in. surface water sewer must be laid, so the governing factor which controls the rate at which the carriageway can be constructed is the rate at which the sewer can be constructed. The bulk excavation must be done at sufficient speed to ensure this rate of surface water sewer laying, whilst the gang putting in the gullies and connections must be so proportioned as to ensure that they also keep up with this rate of sewer laying.

Plant Required

The first item, therefore, to consider is the 9 in. surface water sewer, 3,000 L. yds. long.

1. Assuming this is 8 ft. deep and trench width excavation necessary is 2 ft. 6 in. wide.

   $$\text{Volume of excavation in trench} = \frac{3 \times 8 \times 2{\cdot}5}{27} = 2.20 \text{ cu. yds. per Lin. yd.}$$

2. Assuming a 44 hour week is worked and five months = 22 working weeks.

   Allow for 20 weeks as the starting of the various operations will have to be staggered, as will be seen.

   $$\text{L. yds. to lay per week} \ldots \quad \ldots \quad = \frac{3000}{20} = 150 \text{ L. yds.}$$

   $$\therefore \text{Cu. yds. to excavate per hour} = \frac{150 \times 2{\cdot}20}{44} = 7\tfrac{1}{2} \text{ cu. yds.}$$

   $$\text{L. yds. excavated per hour} = \frac{7{\cdot}50}{2{\cdot}20} = 3{\cdot}40 \text{ L. yds.}$$

It must therefore be arranged to:

1. Have a hand gang to excavate 7½ cu. yds. per hour; or
2. Have a mechanical excavator capable of excavating 7½ cu. yds. per hour.

The Bulk Excavation

Assuming a more or less even depth throughout the length of the road.

The volume which must be handled per week $= \frac{8000}{20} = 400$ cu. yds., and length of carriageway excavation per week $= 3000 \div 20 = 150$ yds.

Working a 44-hour week.

$$\text{Volume to be handled per hour} = \frac{400}{44} = 9 \text{ cu. yds. per hour.}$$

It must therefore be arranged to use a mechanical excavator capable of excavating 9 cu. yds. per hour on this excavation with sufficient means in the way of lorries, dumpers, or whatever plant is decided on to remove this excavation to the shoot.

The Gullies and Connections and the 3 *in. Ashes on the Sub-base*

This simply becomes a matter of arranging that:

1. A gang of sufficient size is used to construct the gullies and connections in order to keep up with the rate of progress of the main surface water sewer, i.e. 150 yds. per week.
2. A gang of sufficient size laying and rolling the ashes on the sub-base.

The Concreting of the 6 *in. Carriageway*

The total area to be covered = 24,000 sq. yds., 6 in. thick = 4,000 cu. yds.

It has been arranged that the surface water sewer be laid at the rate of 150 L. yds. per week.

∴ Area of carriageway possible to lay per week = 150 L. yds. × 8 yds. wide
= 1200 sq. yds.

This means that the area to be laid per hour in a 44-hour work week

$$= \frac{1200}{44} = 28 \text{ sq. yds. approx.}$$

$$= 4\tfrac{2}{3} \text{ cu. yds. approx.}$$

It must therefore be arranged to use a concrete mixer capable of producing $4\frac{2}{3}$ cu. yds. per hour.

Assuming the date set to commence the work is 1st March and the completion date 31st July, the order of procedure would be:

1. An immediate start would be made on the bulk excavation on 1st March. At the end of six working days sufficient site excavation would have been done to permit of the starting of the 9 in. surface water sewer, as approximately 150 yds. of site excavation would have been removed.

2. The 9 in. surface water sewer would then be commenced on the 7th March, followed by the gulley and connection gang and the ash laying gang.

3. By the 13th March sufficient area would be ready for a start to be made on the concreting of carriageway, as in this time approximately 150 yds. of surface water sewer would be laid.

The programme of works would then be as shewn on page 43.

As the time allowed of five months is likely to be enforced, a financial penalty being imposed if the work is not constructed in time, it is important that whilst the work is being constructed the following records should be kept:

1. A record of the weather conditions.
2. Additional works carried out.
3. Dayworks carried out.

These records may prove of value when claiming for an extension of time.

The Administrative Staff Required on the Works

Having drawn up the programme the agent must assess what staff is necessary for the efficient carrying out of the work. In so doing he must see to it that:

The General Site Charges, so far as their cost is concerned, are a reasonable percentage of the total cost of the works. It is usually in the region of 5% but should not exceed this figure.

Regarding staff, his aims must be to: (1) employ only thoroughly experienced staff; (2) to have the minimum staff possible for the efficient carrying out of the work to ensure that its percentage of the cost of the works shall be as small as possible; (3) to construct the work in the shortest possible time by doubling up plant, etc.

Example of Staff required assuming the same typical concrete road contract:

Value of contract . . . . = £30,000
Time to complete . . . . = 20 weeks
∴ Average value per week . . = £1,500

To show 15% gross (assuming the agent has been told by Head Office that this is the amount he has to make).

Then cost of works per week to show 15% gross is:

$$\text{Cost of the work} + (15\% \text{ cost of the works}) = £1{,}500.$$

$$\therefore 1{\cdot}15 \times \text{cost of works} = £1{,}500.$$

$$\therefore \text{Cost of work} = \frac{1500}{1{\cdot}15} = £1{,}304 \text{ per week.}$$

The agent must therefore arrange that the general site charges are not more than 5% say, of £1,304 = £65 4*s*. 0*d*.

For the contract in question he will draw up these charges, somewhat on the following lines:

Weekly General Site Charges	*Cost per week*		
One agent in charge	10	0	0
One engineer setting out, measuring up and costing the work	7	0	0
One general foreman	7	0	0
1 clerk—general	4	10	0
One timekeeper	4	10	0
1 watchman—office	3	0	0
Allowance for small tool depreciation, say	3	0	0
Allowance for coal, coke, postage, stationery and telephone	2	0	0
Allowance for employer's contribution to National Insurance	10	0	0
Allowance for holidays with pay scheme	7	0	0
Allow for hauling and erecting office, also office cleaners . .	3	4	0
	£61	4	0

This works out just inside the 5%, which is all to the good.

$$\text{viz.: } \frac{£61\ \ 4\ \ 0}{£1{,}304} = 4\tfrac{3}{4}\%$$

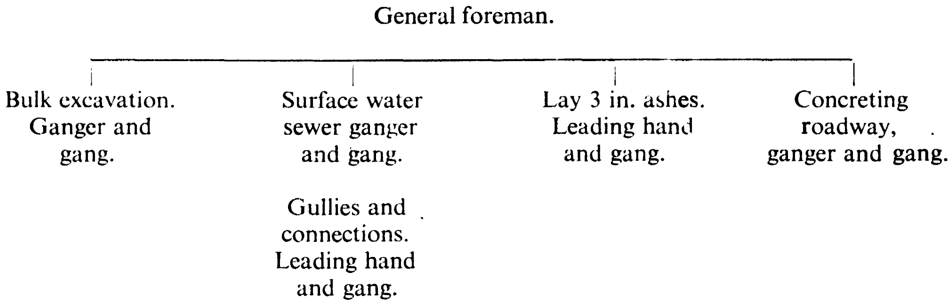
THE PROGRAMME OF WORKS

Description	*Unit*	*Total Quantity to do*	*Commencing Date*	*Output required per week*	*No. of weeks to complete*	*Date of Completion*
Bulk excavation	Cu. yds.	8,000	1st March	400	20	19th July
6 in. surface water sewer	L. yds.	3,000	7th March	150	20	25th July
6 in. concrete roads	S. yds.	24,000	13th March	1,200	20	31st July

The Labour Administration in Charge of the Works

This is carried out by a general foreman with gangers and leading hands under him who control the individual gangs of men.

Assuming the same typical concrete road contract, the set-up of labour supervision would be as shown:


General foreman.
Bulk excavation. Ganger and gang.
Surface water sewer ganger and gang.
Gullies and connections. Leading hand and gang.
Lay 3 in. ashes. Leading hand and gang.
Concreting roadway, ganger and gang.

Note.—A first-class general foreman is of the utmost importance if the job is to be a successful one. His ability to handle men as well as knowledge of the work is a large factor in the ultimate result and it is a fact that a "good general" always has good gangers and good men.

The Plant, Labour and Material Required—Their Co-ordination and Balance

Plant Required

It has been shown previously in this section under "The Programme of Works" how the plant required is arrived at and it has, of course, to be selected to suit the type of work which has to be constructed. The factors which govern the question of plant required and type are:

1. The nature of the work, type of ground to be excavated, etc.
2. The amount of work to be done.
3. The time in which the work has to be done.

The plant is chargeable to the contract on which it is used at a hiring rate per hour which covers all depreciation, driver, fuel, oil, repairs and renewals, Insurance and Licence Cost if any.

(See Section Twenty, devoted to plant working costs per hour.)

Most firms have their own hiring rates for various types of plant and these are furnished to the agent, who costs his work, using these rates, which were those used by the estimator for plant in making up the tender.

Section Eight sets out how much labour is required in attendance on plant in order to carry out the various items of work, giving the correct balance of labour to plant. This is absolutely necessary if low competitive cost is to be achieved.

Section Eight shows at a glance:

1. How to apportion labour to different types and sizes of plant to construct work with the greatest efficiency.
2. Plant output per hour.
3. The material various plants can handle per hour.
4. How long lorries, dumpers, etc., take to haul to tip of various mileages.
5. The apportionment of labour to tradesmen on different types of work.

Labour Required

The amount of labour required on the work, including tradesmen, such as bricklayers, etc., is dependent on:

1. The size and type of the work.
2. The time in which it has to be completed.

It is good policy to keep the amount of labour as small as possible by utilising modern plant. The general tendency is for the foreman and gangers to "over-labour" the job and this must be carefully looked out for.

The agent or engineer is advised to study Section Eight carefully, as the balancing therein contained conforms to well tried principles with a view to:

1. Ensuring that the plant is kept fully occupied.
2. Ensuring that the labour is kept fully occupied.

Two essentials to construction at low cost.

Materials Required

When making up the tender the estimator calls for quotations for the various materials required and makes up his tender on the lowest received, provided these are of good quality. In connection with materials the agent must see to the following points:

1. The materials bought *must not* cost more than tendered on. The usual practice is, having secured the contract, to get in further quotations and buy in the lowest market possible.
2. The materials must be of good quality and approved by the client or authority for whom the work is being carried out.
3. They must all be available in ample quantity to ensure keeping all plant and labour working to capacity and completing the contract in the time allowed.
4. Delivery must be guaranteed by the supplier, to be put into the job at the correct rate so that plant is working efficiently, neither being short of material nor being crowded out with it, necessitating labour cost to handle it later to the plant.

The quantity of loose materials delivered should be carefully checked and measured in the lorry delivering them, in order to ensure that delivery is in agreement with the amount shown on the delivery note, as this is what will have to be paid for. This checking is usually done by the ganger, or, on a large contract, by a material checker. It is a good plan if these men write on the measurements as taken on the delivery notes, as this is useful in the event of dispute.

The essentials in connection with plant, labour and materials from the cost of the work point of view are:

1. The labour used must be correctly apportioned to the various types of work.
2. The proportion of labour to tradesmen must be correct.
3. The correct number of labourers must be used on plant constructing various types of work.
4. The material intake to the job must ensure the plant working to capacity.

All the above are to be found in Section Eight, which forms a guide to the young engineer whose experience and knowledge is limited on these important points.

Progress Charts and the Check on Output

Check on output is necessary in order that:

1. The progress of the work as a whole can be seen.
2. The progress of each main item of the work can be seen.
3. The weekly progress can be seen.

In conjunction with the "programme of the works" these charts show at a glance if the programme is being adhered to.

The progress charts are produced for the main items of work and in the typical concrete road contract, which has been taken as an example, would be drawn for:

1. The bulk excavation.
2. The surface water sewer.
3. The concreting of the carriageway.

The charts are drawn as graphs — the "X" axis or horizontal axis being shown as the date axis, usually divided off in weeks and the "Y" axis or vertical axis showing the work done, divided off in cu. yds., lineal yds., or whatever the unit may be.

Superimposed on this graph, a line is plotted showing the progress line which must be adhered to in order to complete the works in the time allowed, whilst the line showing the actual progress is plotted week by week. Different colours are used for these two lines for clarity. From the graph or chart can then be read at a glance:

1. The progress for the week.
2. The progress to date.
3. If the actual progress is keeping up with the required progress.

Producing the Progress Charts

1. The Actual Progress Graph

Assuming the same typical concrete road contract.

In order to produce the progress charts the work has to be measured up weekly by the engineer or surveyor and the quantity of work done under the various items worked out. This has to be done anyway if costs are to be kept and an abstract is kept for both the quantity of work done for the week in question, as well as the progressive quantity done. A simple method of doing this is as shown in the table overleaf.

This also gives the information necessary to plot the graph on the progress chart.

MEASUREMENT ABSTRACT OF WORK DONE

Contract: LENDEN *Week ending:* 15th March, 1943

Description	*Unit*	*Week's Quantity*	*Previous Quantity*	*Total Quantity to Date*
Bulk excavation	cu. yds.	400	200	600
Lay 9 in. surface water sewer . .	L. yds.	140	160	300
Concrete roadways	S. yds.	1,200	800	2,000

2. THE PROGRESS REQUIRED GRAPH

The information required to produce this graph is found from the "Programme for the Works" shown earlier in this section, when the following position was arrived at:

PROGRAMME OF WORKS

Description	*Unit*	*Commencing date*	*Total Quantity to do*	*Output Required per week*	*No. of weeks to complete*	*Completion date*
Excavation	Cu. yds.	1st March	8,000	400	20	19th July
9 in. surface water sewer	L. yds.	7th March	3,000	150	20	25th July
6 in. concrete roads . .	S. yds.	13th March	24,000	1,200	20	31st July

From the above it will be seen that the bulk excavation has to be completed in 20 weeks, the starting date being 1st March and the completion date 19th July. Similarly the surface water sewer and concrete road has to be done in 20 weeks commencing the 7th and 13th March, respectively.

Method of Plotting the Progress Charts

This will be shown for the bulk excavation only as the same method applies to both the 9 in. surface water sewer and 6 in. concrete road.

Bulk Excavation Graph for Actual Progress

The "X" or horizontal axis will start with the date, 1st March, as shown on the programme of works and the "Y" axis will range from 0 cu. yds. at its junction with the "X" axis to 8,000 cu. yds. (the total quantity to be done) at the top. For the week in question, viz.: ending 15th March (as shown in measurement abstract), the total quantity or progressive quantity of bulk excavation done to that date is 600 cu. yds., and this is therefore plotted along the "Y" axis, corresponding to the week of the 15th March on the "X" axis. By plotting this weekly a series of points are obtained, which when joined together produce the actual progress graph. This is usually plotted in black ink.

Excavation Graph for Required Progress

This is simply done, as 8,000 cu. yds. have to be done in 20 weeks.

A point is simply plotted on the 8,000 cu. yd. mark on the "Y" axis opposite the twentieth week (19th July) on the "X" axis and the graph is a straight line drawn from the intersection of the "X" and "Y" axis where dated 1st March on the "X" axis and 0 cu. yds. on the "Y" axis to this point.

This line is usually drawn in red and the actual progress graph should conform with this red line if the rate of progress required to complete in the time allowed is to be achieved.

In the typical graph shown it will be noted that the actual progress was less than required for a start but then gained, and that the total excavation was completed one week before the time counted on. This is all to the good and it should constantly be the endeavour of the administrative staff to "complete ahead of schedule".

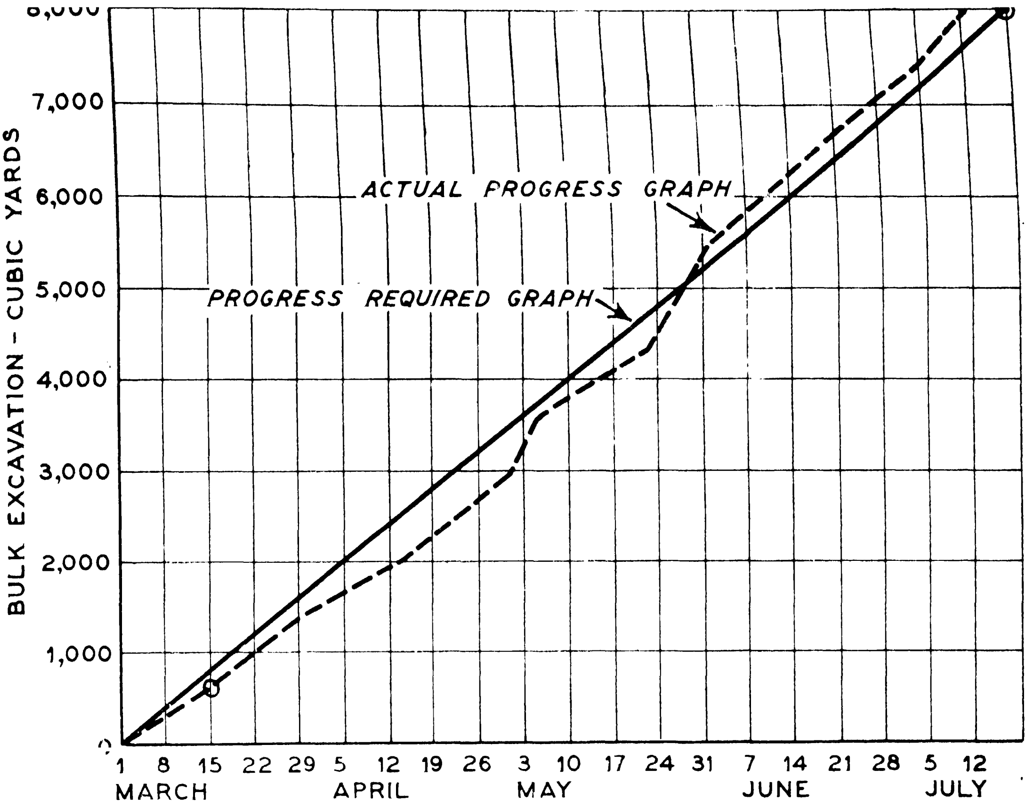


FIG. 2.—PROGRESS CHART; BULK EXCAVATION

The graphs of the 9 in. water sewer and the 6 in. concrete roadways are produced in an exactly similar manner, the only difference being that:

1. The starting and finishing dates are as shown on the programme of works.
2. The "Y" axis would be lineal yds. of 9 in. surface water sewer in the one case and sq. yds. of 6 in. concrete roadway in the other.

By studying the progress charts individually and collectively the agent can see how the work is progressing in all its main branches.

This method of showing progress by graphs is eminently suitable for works which do not embody many component operations, such as a sewer contract, where only three graphs showing progress might be necessary, viz.:

(1) Trench Excavation,
(2) Pipe Laying, and
(3) Trench Refilling.

On works of a large nature, however, where there are many different component operations, a whole series of graphs would be required were this system adopted. This would be impractical and confusing as it is obviously advantageous to have the position of the work recorded on as few graphs or charts as possible, so that the progress of the work may be seen as a whole. For this reason, the Progress Chart System shown is usually adopted, this one chart embodying all the main component operations, which it is thought desirable to "Programme and Progress".

Programming and Progress Charts

On Civil Engineering Works, having many component operations, it is of the utmost importance to plan or programme the manner in which the component operations will be carried out and also in which sequence they will be started.

This Programming consists of:

(1) Considering the various component operations of work which have to be carried out.
(2) The sequence in which they should be carried out.
(3) The dates on which each operation should be started and finished.
(4) Ensuring that the whole dovetails together so that the work progresses smoothly to its conclusion, within the time allowed for the completion of the contract.

Having drawn up the Programme, compute from it:

(1) What plant will be required to carry out each component operation of work and when it must be on the site ready to go to work to complete in the programme time.
(2) What labour will be required to carry out each component operation of work in the programme time.
(3) What materials and daily rate of material delivery will be required to complete in the programme time.

It is here emphasised that great care and thought should be given to this programming of the work. It forms the target at which is aimed the whole of the effort and adherence to the programme ensures a sweet running contract, carried out efficiently, without delays and hitches which cause disorganisation with consequent loss of time and money.

Both the Programming and Progress Chart must be adaptable, as few contracts are carried out without some alterations or change of policy as the works proceed. The Chart is therefore drawn up in such a form that it can be readily adapted to any major change in policy or alteration in the work.

Progress Charts

Under this system the programme is drawn up in the form of a chart, which same chart has recorded on it, the progress as actually carried out. Each component operation must progress to programme, i.e. the two must keep in step and it is essential that this be so, for it is obvious that if in the construction of a runway, 20,000 sq. yds. of concrete has been programmed per week, and is being laid, while only 15,000 sq. yds. of excavation is done per week, i.e. 5,000 sq. yds. short of the programmed amount, then chaos is bound to result. The excavation must obviously be speeded up to the programmed amount otherwise the concreting will be stopped, as it will overrun the excavation, causing considerable disorganisation.

The Information which can be obtained from the Programme Progress Charts

The Progress Charts are of great use, and from them can be obtained the position of the work under all its component operations at the end of each current week. From the charts can be seen at a glance the following:

(1) When the various component operations have to be started and when they have to be completed.

(2) How much work has been done under each component operation at the end of the current week.

(3) When these component operations were started, and having completed them, when they were finished.

(4) Whether the actual progress is keeping up with the programmed amount.

(5) Knowing when each component operation has to be started, and the time in which it has to be completed, the engineer in charge of the works of construction can assess what plant, labour and materials will be required, to what amount these will be required, and when they must be ready in order to proceed with the work on the programmed date.

It will, therefore, be appreciated that the charts are of the greatest use not only to the engineer in charge of construction, who must co-ordinate the whole of the work, but also to the Head Office staff who periodically visit the site, as from these charts they can see exactly how the job stands. If any operation is out of step with the programme, and is behind, measures can at once be taken to rectify this state of affairs.

As stated before, the programming should be thoroughly and carefully planned and the recording of the actual progress on the chart itself should be accurately carried out so that the position shown is a true record of the actual state of affairs.

Preparing the Programme Progress Chart

In order to show in as simple a manner as possible how these charts are prepared, four simple charts have been included.

These are designed to show how the Programme Progress Chart is "built up".

In connection with these charts the following should be noted:

(1) The figures on the top line denote the estimated progressive quantity of the component operation which can be carried out.

(2) The hatched line denotes the programme and shows when this operation should be started and when it should be completed. This hatched line denotes both time and quantity.

(3) The thick black line denotes the actual progress made and this is recorded on the chart weekly.

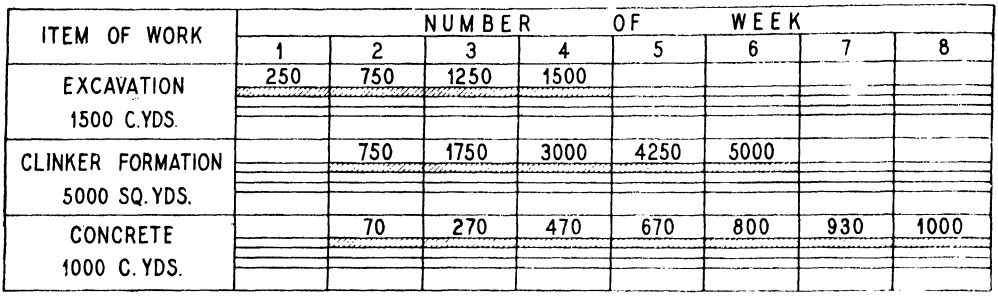
(4) The figures on the bottom line denote the actual progressive quantity of the component operation done.

CHART NO. 1

This chart is the Programme Chart and for purposes of illustrating the method of charting programme and progress on a contract, a simple concrete road contract involving excavation, clinker foundation and concrete carriageway has been taken.

The figures on the top row denote the progressive quantity of the component operation it has been estimated can be carried out, while the hatched line denotes the programme and shows the weeks on which this operation must be started and finished.

CHART I



PROGRAMME CHART

CHART No. 2

This shows the Programme and Progress Chart at the end of the first week's work. It will be noted that:

(1) Only the excavation has been started.

(2) That it was started on programme time.

(3) That only 125 cu. yds. were actually excavated as compared with the estimated 250 cu. yds. This is shown by recording the black or progress line as only half of the hatched line for this first week.

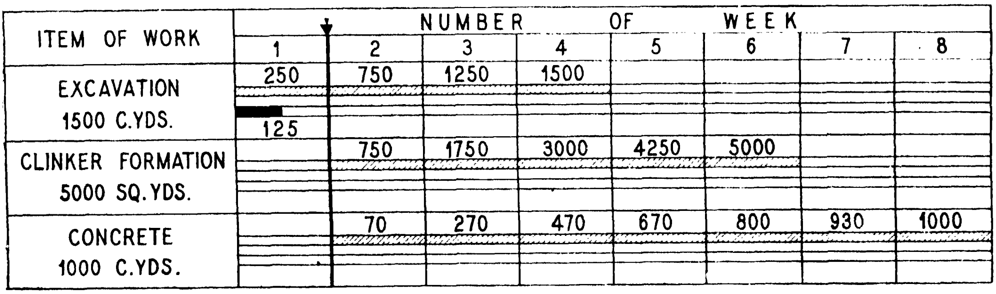
The position of the contract at the end of the first week is therefore:

(*a*) Only the excavation has been started.

(*b*) That the excavation is 125 cu. yds. behind programme.

(*c*) That the contract is half week behind programme.

CHART 2



PROGRAMME AND PROGRESS CHART AT END OF FIRST WEEK

CHART No. 3

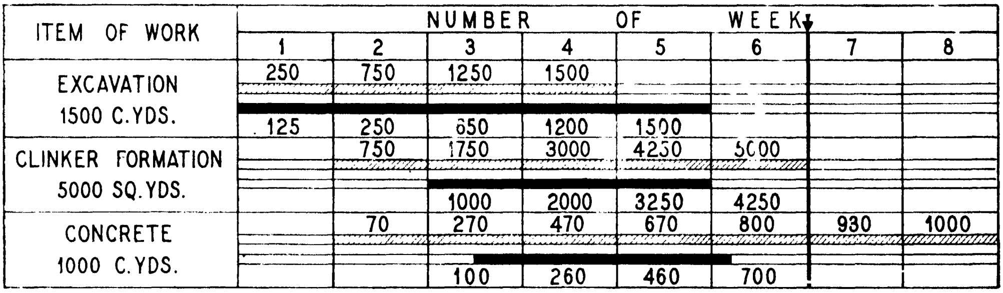
This shows the Programme and Progress Chart at the end of the sixth week's work. It will be noted that now, all the component operations are under way. By examining the chart the following information can be deduced:

(1) The excavation which started on the programme date is now completed but took five weeks to do, and finished one week later than the estimated programme.

(2) The clinker formation was started one week late and is 750 sq. yds. behind programme and is also one week behind programme.

(3) Concreting was started one and a half weeks late and is now 100 cu. yds. and almost a week behind programme.

CHART 3



ITEM OF WORK	1	2	3	4	5	6	7	8
EXCAVATION 1500 C.YDS.	250	750	1250	1500				
	125	250	650	1200	1500			
CLINKER FORMATION 5000 SQ.YDS.		750	1750	3000	4250	5000		
			1000	2000	3250	4250		
CONCRETE 1000 C.YDS.		70	270	470	670	800	930	1000
			100	260	460	700		

PROGRAMME AND PROGRESS CHART AT END OF SIXTH WEEK

CHART No. 4

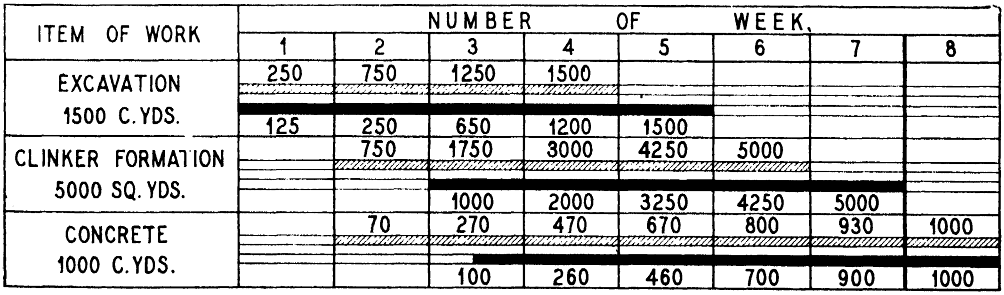
This shows the Programme and Progress Chart at completion of the contract. Analysing this final chart the following can be deduced:

(1) Excavation took five weeks instead of the programmed four weeks.

(2) Clinker formation was started a week late and finished a week late. This was probably due to the fact that the excavation was too slow in the first two weeks.

(3) Concrete was finished on time, viz. at the end of the eighth week. This was possible as it will be noted that in the sixth and seventh weeks 130 cu. yds. was programmed for, but actually 200 cu. yds. were laid, leaving only 100 cu. yds. to do in the eighth week. The contract was therefore complete in the specified time allowed, viz. eight weeks.

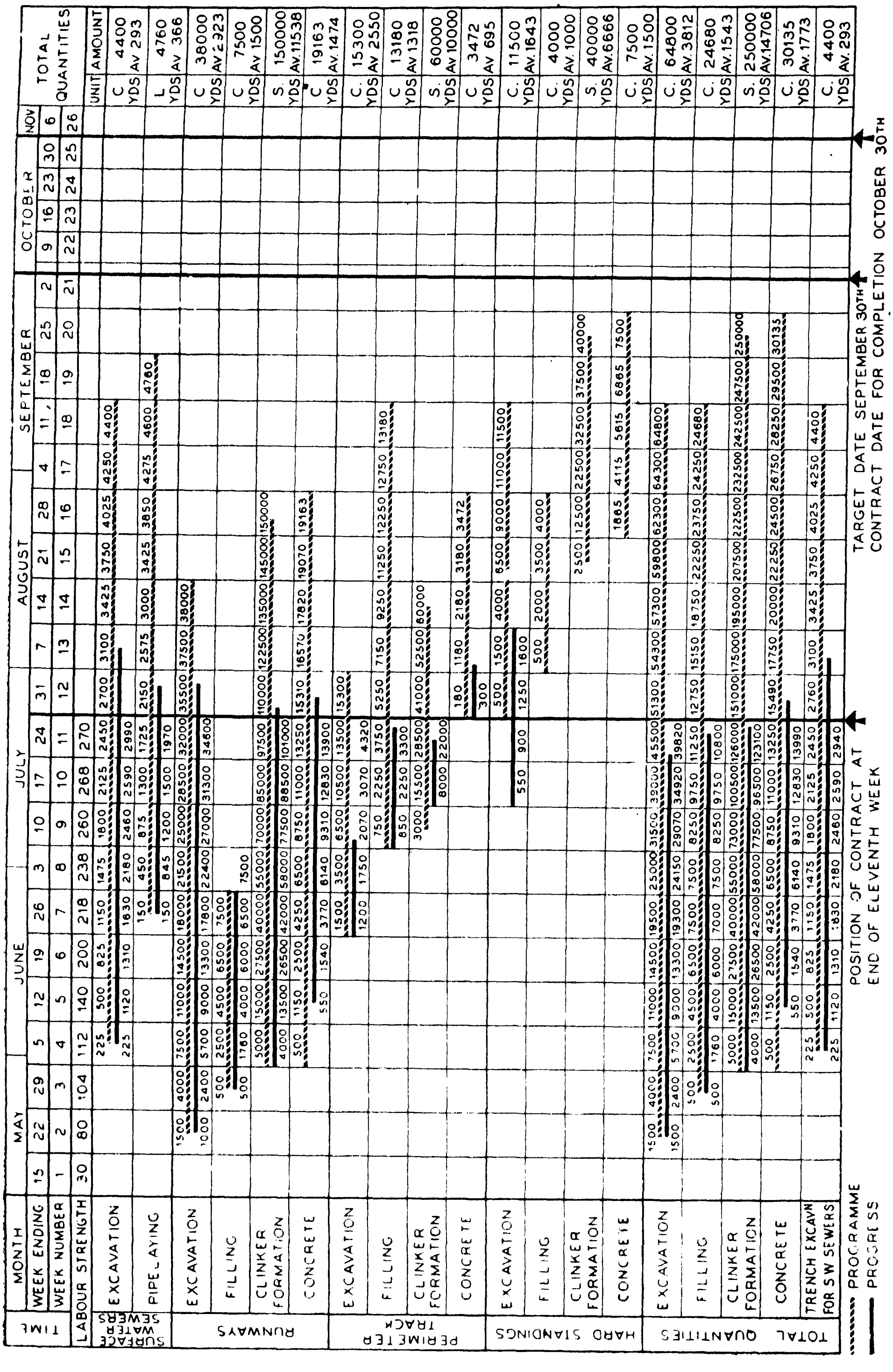
CHART 4



ITEM OF WORK	1	2	3	4	5	6	7	8
EXCAVATION 1500 C.YDS.	250	750	1250	1500				
	125	250	650	1200	1500			
CLINKER FORMATION 5000 SQ.YDS.		750	1750	3000	4250	5000		
			1000	2000	3250	4250	5000	
CONCRETE 1000 C.YDS.		70	270	470	670	800	930	1000
			100	260	460	700	900	1000

PROGRAMME AND PROGRESS CHART AT COMPLETION OF CONTRACT

CHART 5



PROGRAMME AND PROGRESS CHART: GEDNOL AERODROME

Chart No. 4 is the chart in its correct form, as the Programme Progress Chart is one single chart, the others having been shown simply to show the build-up of the chart in its final form.

Having shown in detail the method of drawing up a Programme Progress Chart, a complete chart for works in connection with a new aerodrome is shown in Chart 5.

Complete Chart for Aerodrome Contract

This Chart embodies:

(1) Surface water drainage.
(2) Runway construction.
(3) Perimeter track construction.
(4) Hard-standing construction.

It will be noted that one column shows the labour strength from week to week and that the various items of work as actually carried out have been summarised at the bottom of the chart, so that the position of the contract, as a whole, can be readily seen. The progress is shown at the end of the eleventh week. Extra columns may be included to allow for any possible alterations or additions, which might alter the programme by lengthening the period of time to complete the contract.

On a chart of this nature it is not possible to include every single item of work and it is customary to chart the major operations which form the main part of the contract only.

On some contracts both graphs and charts may be used, the graphs being the best way of recording single component operations, where great accuracy is desired. For large works, where it is advantageous to see all components of work recorded under one's eye on one chart, so that the position as a whole may be quickly judged, the Programme Progress Chart is best. These charts should be kept as simple, concise, and neat as possible, as if it is too detailed it cannot be readily understood. The information recorded should be accurately plotted so that a really true state of affairs can be seen, week by week, as the contract progresses to its conclusion.

SECTION EIGHT

★

PLANT AND LABOUR TO USE

This Section shows the correct apportionment of labour to plant, and the labour required with tradesmen to construct various works.

It indicates at a glance:

1. How many labourers to use to construct various types of work.
2. The proportion of labourers to tradesmen to use to construct various types of work.
3. The number of labourers to use with different types of plant in constructing various types of work.
4. The hours taken to fill lorries and dumpers by mechanical excavators and the time taken to haul to tip at various lengths of haul.
5. The average output of various plants per hour.
6. The average output of labour per hour in carrying out various types of work.

The above have been carefully arrived at, and follow well tried and general practice with the object of ensuring that:

1. The plant is working to capacity.
2. The labour is kept constantly employed.
3. The work is constructed efficiently and at minimum cost.

It is most important if the job is to prove a success, both from a progress point of view and a financial one, that this balancing of labour and plant is carefully studied and watched on the works whilst they are being carried out.

There are, of course, occasions when this set-up may have to be altered, due to site conditions, etc., but this Section should prove of use particularly to the young engineer whose experience and knowledge is still limited, who can use it as a guide in the running of the work.

It is a fact that the writer has been really surprised by the lack of knowledge of the above fundamentals which he has seen displayed on some works of construction, and their importance cannot be over-emphasised.

The general tendency is for the foreman or ganger to have too many men and this state of affairs should be carefully watched for, and if necessary, corrected.

The estimator may look upon the data as tabulated as a guide for labour apportionment and plant and labour output in carrying out work of various kinds under normal conditions. Discretion should be exercised in using the data as specific circumstances do arise which affect both apportionment and outputs such as adverse site conditions, inaccessibility, etc. Such circumstances should be taken into account.

From the plant and labour outputs shown an assessment may be made of the plant required and the labour strength necessary to carry out certain works of known amount in a given time.

Plant Output per Hour

OUTPUT OF DRUM AND HOPPER TYPE CONCRETE MIXERS OF VARIOUS SIZES

Type of mixer	*Capacity of dry aggregate, sand and cement. Cubic feet per mix*	*Mixed concrete output. Cubic feet per mix*	*Average output of mixed concrete in cubic yards per hour*
5/3½	5	3½	1½
7/5	7	5	2½
10/7	10	7	4
14/10	14	10	5
21/14	21	14	7

OUTPUT IN CUBIC YARDS PER HOUR OF THE LARGER SIZED CONCRETE MIXERS OF THE DRUM AND HOPPER TYPE LOADED BY HAND AND BY MACHINE

Method of loading mixer	*Size of mixers and type of work and output in cubic yards per hour*					
	10/7		14/10		21/14	
	Large areas, roads, etc., or mass concrete	*Normal foundations, floors, etc.*	*Large areas, roads, etc., or mass concrete*	*Normal foundations, floors, etc.*	*Large areas, roads, etc., or mass concrete*	*Normal foundations, floors, etc.*
By Hand	4·00	2·66	5·00	3·75	7·00	5·80
By Hi-lift shovel	4·80	3·20	6·00	4·50	8·40	7·00
By dragline	5·00	3·36	6·25	4·70	8·64	7·20
By grab ..	5·20	3·50	6·50	4·90	9·00	7·50

OUTPUT OF MECHANICAL EXCAVATING PLANT OF VARIOUS KINDS IN CUBIC YARDS PER HOUR

Note.—Table is shown for easy digging in soft or loamy sand and soil. Use multipliers shown for other classes of ground.

Bucket Capacity of machine in Cubic Yards	*Output in cubic yards per hour and type of machine excavating and loading soft sand*			
	Shovel or Dragline	*Skimmer*	*Backacter*	*Grab*
¼	16	12	11	6
⅜	26	20	18	9
½	36	27	24	14
⅝	54	41	36	23
¾	62	47	41	27
⅞	72	54	48	32
1	82	61	54	36

MULTIPLIERS FOR USE WITH THE PRECEEDING TABLE FOR VARIOUS CLASSES OF GROUND

Type of Machine	*Soft Sand*	*Soil or Firm Sand*	*Average Loamy Ground or Soil, Loamy Clay*	*Broken Rock or Metal*	*Stiff Clay or Hard Gravel*	*Soft Chalk*
Shovel . .	1·00	0·80	0·70	0·60	0·50	0·35
Skimmer . .	1·00	0·80	0·70	0·60	0·50	0·35
Dragline . .	1·00	0·80	0·70	0·60	0·50	—
Backacter . .	1·00	0·80	0·70	0·60	0·50	0·35
Grab	1·00	0·60	0·40	0·30	0·20	0·10

For Excavation.—The type of ground most usually met with is average loamy ground as shown in thi column.

OUTPUT OF TRACTORS AND SCRAPERS EXCAVATING LOAMY SAND OR SOIL CUBIC YARDS PER HOUR

Type of tractor	*Size of scraper Cu. yd*	*Length of haul in yards and output per hour in cubic yards*				
		100 *yards*	200 *yards*	300 *yards*	400 *yards*	500 *yards*
		Cu.yds/hr.	*Cu.yds/hr.*	*Cu.yds/hr.*	*Cu.yds/hr.*	*Cu.yds/hr.*
D4	4	24	18	16	14	12
D6	6	36	27	23	20	17
D7	8	48	36	30	26	23
D8	12	72	54	44	38	35

MULTIPLIERS FOR USE WITH THE ABOVE TABLE FOR VARIOUS CLASSES OF GROUND

Nature of ground	*Multiplier*
Loamy sand or soil . .	1·00
Loamy clay or gravel . .	0·90
Firm clay	0·85
Hard gravel	0·75

OUTPUT OF PUMPS IN GALLONS PER MINUTE

Type of pump	*Gallons per minute*
3″ petrol single diaphragm	60
4″ ,, ,, ,, ...	100
4″ ,, double ,, ...	200
5″ centrifugal pump	400
6″ ,, ,, ...	600
8″ ,, ,, ...	800
3″ hand pump single diaphragm . .	30

Haulage of materials excavated and loaded by mechanical excavators of the skimmer and shovel type

This is usually carried out by tipping lorries or dumpers, depending on the length of haul. The size of lorry required depends both on the rate the excavator fills and the length of haul to the tip. A table is shown giving the average time taken to fill various sized lorries or dumpers, using different sized excavators. This is based on normal ground such as loamy clay, etc., and on average conditions. A table is also shown giving the average time taken to travel to the tip, tip the material, return to the excavator and set ready for the next load. These times allow for all normal delays, etc., and have been averaged over actual working conditions. From this data the table showing the number of lorries to use has been worked out. In this table the figures shown with no brackets round them denote the number of lorries required to the nearest round figure above the theoretical figure as worked out, while those in parentheses show the most suitable size to use with the excavator so as to maintain steady output.

With small excavators large lorries are uneconomical as theoretically a little over one lorry is required, and in actual fact two would have to be used. This applies in general to all cases where the loading time is greater than the time to haul.

THE TIME TAKEN IN HOURS TO FILL LORRIES, ETC., PER LOAD. LOADED BY MECHANICAL SKIMMERS OR DRAGLINES

Note.—(1) Time allows for all normal working conditions.
(2) Ground is average, such as loamy clay soil, capable of being readily dug by machine.
(3) For mechanical shovels use a multiplier of 0·90 with the hours shown in this table.
(4) For cu. yds. hauled by various sized lorries per load, see p. 59.

Excavator bucket capacity in cu. yards	*Size of lorries and dumpers and average time to fill in hours*						
	2 *ton lorry*	3 *ton lorry*	4 *ton lorry*	5 *ton lorry*	6 *ton lorry*	2 *cu. yard dumper*	3 *cu. yard dumper*
¼	0·20	0·30	0·40	0·50	0·60	0·20	0·30
⅜	0·14	0·20	0·27	0·34	0·41	0·14	0·21
½	0·10	0·15	0·20	0·25	0·30	0·10	0·15
⅝	0·09	0·13	0·17	0·21	0·25	0·09	0·13
¾	0·07	0·10	0·14	0·17	0·21	0·07	0·10

THE TIME TAKEN IN HOURS PER LOAD TO TRAVEL TO TIP, OFF-LOAD AND RETURN

Note.—(1) Lorries are tipping lorries—mechanical.
(2) For cubic yards hauled by various sized lorries per load, see p. 59.
(3) Lorries assumed to run on roadways or good firm level ground.

Plant used on haulage	*Length of haul from site to the tip in yards and miles*						
	220 *yards*	440 *yards*	660 *yards*	880 *yards*	1 *mile*	2 *miles*	3 *miles*
Lorries ..	0·09	0·12	0·14	0·16	0·28	0·40	0·56
Dumpers..	0·10	0·14	0·17	0·20	—	—	—

HAULAGE OF EXCAVATED MATERIALS

Tables showing the number of lorries or dumpers of various capacities to use on haulage of excavated material to various lengths of haul when filled by different sizes of mechanical excavators fitted with skimmer or shovel equipment.

Note.—(1) Lorries are tipping lorries with mechanically operated tipping gear.

(2) Dumpers are only suitable for hauls up to ½ mile maximum. Their most economical haul is up to about ¼ mile over open ground where lorries cannot travel.

Excavator bucket capacity	*Lorry or dumper*	*Number of vehicles and length of haul*					*Excavator bucket capacity*	*Lorry or dumper*	*Number of vehicles and length of haul*				
		220 *yds.*	880 *yds.*	1 *mile*	2 *miles*	3 *miles*			220 *yds.*	880 *yds.*	1 *mile*	2 *miles*	3 *miles*
¼ cu. yd.	2 ton	(2)	(2)	3	4	5	⅜ cu. yd.	2 ton	(2)	3	4	5	6
	3 ,,	2	2	3	3	4		3 ,,	2	(2)	3	4	5
	4 ,,	2	2	(2)	3	3		4 ,,	2	2	3	(3)	4
	5 ,,	2	2	2	(2)	3		5 ,,	2	2	(2)	3	(3)
	6 ,,	2	2	2	(2)	3		6 ,,	2	2	(2)	6	3
	2 cu. yd.	(2)	2	–	–	–		2 cu. yd.	(2)	3	–	–	–
	3 ,,	(2)	(2)	–	–	–		3 ,,	(2)	(2)	–	–	–

Excavator bucket capacity	*Lorry or dumper*	*Number of vehicles and length of haul*					*Excavator bucket capacity*	*Lorry or dumper*	*Number of vehicles and length of haul*				
		220 *yds.*	880 *yds.*	1 *mile*	2 *miles*	3 *miles*			220 *yds.*	880 *yds.*	1 *mile*	2 *miles*	3 *miles*
½ cu. yd.	2 ton	(2)	3	(4)	(5)	7	⅝ cu. yd.	2 ton	(2)	4	5	(6)	8
	3 ,,	(2)	3	4	5	6		3 ,,	(2)	3	4	(5)	7
	4 ,,	2	(2)	(3)	4	5		4 ,,	(2)	3	4	5	6
	5 ,,	2	(2)	3	(3)	(4)		5 ,,	2	3	(3)	4	5
	6 ,,	2	(2)	3	(3)	4		6 ,,	2	(2)	3	4	(4)
	2 cu. yd.	3	4	–	–	–		2 cu. yd.	(3)	(4)	–	–	–
	3 ,,	(2)	3	–	–	–		3 ,,	(2)	(3)	–	–	–

Excavator bucket capacity	*Lorry or dumper*	*Number of vehicles and length of haul*					*Excavator bucket capacity*	*Lorry or dumper*	*Number of vehicles and length of haul*				
		220 *yds.*	880 *yds.*	1 *mile*	2 *miles*	3 *miles*			220 *yds.*	880 *yds.*	1 *mile*	2 *miles*	3 *miles*
¾ cu. yd.	2 ton	3	(4)	6	8	(10)	⅞ cu. yd.	2 ton	(3)	5	7	(9)	(13)
	3 ,,	3	4	5	(6)	8		3 ,,	3	(4)	6	8	(10)
	4 ,,	(2)	3	4	5	(6)		4 ,,	(2)	(3)	(4)	6	(7)
	5 ,,	2	3	(3)	4	5		5 ,,	(2)	3	4	5	(6)
	6 ,,	2	3	3	4	5		6 ,,	(2)	3	4	5	6
	2 cu. yd.	(3)	5	–	–	–		2 cu. yd.	4	(5)	–	–	–
	3 ,,	3	4	–	–	–		3 ,,	(2)	(4)	–	–	–

Note.—Figures not in parentheses denote practical number of lorries required.

Figures in parentheses denote most suitable type and number to use for haul for each particular machine's output, so as to keep both excavators and lorries constantly at work.

HAULAGE OF EXCAVATED MATERIALS

Cubic yards of various types of ground hauled by different types and capacities of haulage plant per load.

Nature of ground hauled	*Weight cu. yds. per ton*	*Haulage plant used and cubic yards solid excavation hauled per load*							
		2 ton lorry	*3 ton lorry*	*4 ton lorry*	*5 ton lorry*	*6 ton lorry*	*2 cu. yd. dumper*	*3 cu. yd. dumper*	*1 cu. yd. Decauville skip*
Soft loamy sand	0·80	1·60	2·40	3·20	4·00	4·80	1·50	2·25	0·75
Firm soil or gravel	0·75	1·50	2·25	3·00	3·75	4·50	1·50	2·25	0·75
Average ground loamy, clay and broken rock	0·72	1·44	2·16	2·88	3·60	4·32	1·50	2·25	0·75
Stiff clay	0·60	1·38	2·07	2·76	3·45	4·14	1·50	2·25	0·75
Chalk	0·67	1·33	2·00	2·68	3·35	4·02	1·50	2·25	0·75

TABLE SHOWING FUEL AND OIL REQUIRED BY VARIOUS PLANTS PER WORKING HOUR

Type of Plant	*Fuel required per hour*				*Lubricating oil galls./hr.*
	Coal cwts./hr.	*Diesel oil galls./hr.*	*Vaporising oil galls./hr.*	*Petrol galls./hr.*	
Compressors, 2 tool petrol	—	—	—	1·30	0·02
2 ,, diesel	—	0·80	—	—	0·02
3 ,, petrol	—	—	—	1·50	0·03
3 ,, diesel	—	1·00	—	—	0·03
Concrete mixers, 7/5	—	—	—	0·50	0·02
10/7	—	—	—	0·60	0·03
14/10	—	—	—	0·70	0·04
21/4	—	—	—	1·00	0·05
Crane, 8 cwt. petrol	—	—	—	0·80	0·03
12/15 ,,	—	—	—	1·00	0·04
20 ,,	—	—	—	1·40	0·06
3 ton steam	1·00	—	—	—	0·06
Dumper, 2 cu. yd.	—	—	—	1·00	0·03
3 ,,	—	—	—	1·30	0·04
Excavator, bucket trencher, 25	—	—	—	1·70	0·06
12/18	—	—	—	1·30	0·05
Mechanical Excavator, ¼ cu. yd. vaporising or diesel	—	0·70	1·20	—	0·04
⅜ ditto	—	0·80	1·30	—	0·05
½ ditto	—	1·00	1·40	—	0·06
High-lift shovel, ½ cu. yd.	—	—	—	0·90	0·03
Hoist, petrol	—	—	—	0·70	0·02
Locos, 20 h.p. petrol	—	—	—	1·20	0·04
,, diesel	—	0·80	—	—	0·04
Lorries, petrol, 2 ton	—	—	—	0·90	0·02
,, 3 ,,	—	—	—	1·00	0·03
,, 4 ,,	—	—	—	1·00	0·04
,, 5 ,,	—	—	—	1·20	0·05
,, 6 ,,	—	—	—	1·30	0·06
Pumps, 3″ petrol	—	—	—	0·50	0,02
4″ ,,	—	—	—	0·60	0.03
5″ ,,	—	—	—	0·80	0·04
6″ ,,	—	—	—	1·00	0·05
Roller, 2-ton petrol	—	—	—	0·70	0·03
4 ,, ,,	—	—	—	0·90	0·04
6–8 ,, diesel	—	1·00	—	—	0·05
6–8 ,, steam	0·80	—	—	—	0·04
8–10 ,, ,,	1·00	—	—	—	0·05
D4 Tractor with scraper	—	1.70	—	—	0·05
D6 ,, ,, ,,	—	2·00	—	—	0·06
D7 ,, ,, ,,	—	2·90	—	—	0·07
D8 ,, ,, ,,	—	4·00	—	—	0·08

Increase in bulk of various materials after digging

Nature of ground	*Before digging*	*After digging*
Sand ..	1·00	1·05
Gravel ..	1·00	1·10
Soil	1·00	1·25
Loamy clay ..	1·00	1·40
Stiff clay ..	1·00	1·50
Chalk ..	1·00	1·60
Lump rock ..	1·00	1·70

Excavation in bulk and over areas. Labour output of a labourer in cubic yards per hour

Description	*Type of ground and cubic yards per hour for one labourer*						
	Sand	*Soil*	*Loamy clay*	*Stiff clay*	*Gravel*	*Soft chalk*	*Hard chalk*
Excavate and fill barrows.. ..	1·10	0·90	0·80	0·70	0·60	0·33	0·20
„ „ „ carts, lorries or dumpers ..	1·00	0·80	0·75	0·66	0·55	0·30	0·18
Wheel barrows to 25 yards ..	2·00	1·66	1·25	1·10	1·66	1·66	1·40
Spread and level	4·00	3·60	3·00	2·50	3·80	3·50	3·30
Fill and ram in banks	1·60	1·60	1·50	1·40	1·70	1·60	1·50

Excavate small foundations such as for building walls, kerb, etc. Labour output of a labourer in cubic yards per hour

Description	*Type of ground and cubic yards per hour for one labourer*						
	Sand	*Soil*	*Loamy clay*	*Stiff clay*	*Gravel*	*Soft chalk*	*Hard chalk*
Excavate small foundations and load to barrows	0·60	0·50	0·45	0·40	0·33	0·20	0·12
Excavate and fill carts, lorries or dumpers	0·54	0·45	0·40	0·33	0·30	0·18	0·10
Wheel barrows to 25 yards ..	2·00	1·66	1·25	1·10	1·66	1·66	1·40
Spread and level	4·00	3·60	3·00	2·50	3·80	3·50	3·30
Fill and ram in banks	1·60	1·60	1·50	1·40	1·70	1·60	1·50

LABOUR OUTPUT PER HOUR

Breaking out existing roads and paths. Labour output in cubic yards per labourer per hour

Description	*Cu. yds. per labourer per hour*
Break out concrete roads	0·07
„ „ hardcore only	0·25
„ „ waterbound roads and hardcore under	0·20
„ „ tarmac „ „ „ „	0·18
„ „ „ paths „ „ „	0·25
„ „ gravel „ „ „ „	0·30

Excavate and refill trenches. Labour output in cubic yards per labourer per hour

Trench depth in feet	*Loamy soil or clay*	*Stiff clay and gravel*	*Soft chalk*	*Hard chalk*
Up to 5 feet	0·29	0·24	0·22	0·10
5–10 „	0·17	0·14	0·14	0·06
10–15 „	0·13	0·11	0·10	0·04
15–20 „	0·10	0·08	0·08	0·03

Note.—Refill and ram trenches only: 1 cubic yard per labourer per hour.

EXCAVATE TUNNELS

Output per miner excavating in cubic yards per miner per hour

Nature of ground	*Area of face and cubic yards per miner per hour*				
	2 *sq. yds.*	3 *sq. yds.*	4 *sq. yds.*	5 *sq. yds.*	6 *sq. yds.*
Loamy soil or clay	0·42	0·44	0·46	0·49	0·50
Stiff clay . .	0·38	0·40	0·42	0·44	0·46
Soft chalk and gravel	0·33	0·34	0·36	0·38	0·39
Hard friable rock and hard chalk . .	0·21	0·22	0·23	0·24	0·25

Note.—The rock is assumed to be hard but friable and fissured.

BRICKLAYING TO WALLS—STOCK BRICKS

Bricklayer output in square yards per bricklayer per hour

Thickness of walls in inches	*No. bricks laid per bricklayer per hour*	*Size of bricks and square yards per bricklayer per hour*		
		$8\frac{3}{4}'' \times 4\frac{3}{16}'' \times 2''$	$8\frac{3}{4}'' \times 4\frac{3}{16}'' \times 2\frac{5}{8}''$	$8\frac{3}{4}'' \times 4\frac{3}{16}'' \times 2\frac{7}{8}''$
4½	50	0·80	1·00	1·12
9	60	0·50	0·62	0·68
14	70	0·38	0·48	0·52

BRICKWORK—FACINGS

Bricklayer output in square yards per bricklayer per hour

Description	*No. bricks laid per bricklayer per hour*	*Size of bricks and square yards per bricklayer per hour*		
		$8\frac{3}{4}'' \times 4\frac{3}{16}'' \times 2''$	$8\frac{3}{4}'' \times 4\frac{3}{16}'' \times 2\frac{5}{8}''$	$8\frac{3}{4}'' \times 4\frac{3}{16}'' \times 2\frac{7}{8}''$
Single facings—English bond	40	0·44	0·55	0·60
„ „ Flemish „	40	0·50	0·62	0·66
Single face—4½″ cavity work	40	0·70	0·83	0·90
Solid 9″ double-faced work	40	0·33	0·40	0·45

PIPELAYER

Lineal yards of pipes laid per pipelayer per hour

Diameter of pipe in inches	*Type of pipes and lineal yards laid per pipelayer per hour*						
	Asbestos cement pipes	*Concrete tubes*	*Cast iron pipes*				*Stoneware pipes*
			Class A	*Class B*	*Class C*	*Class D*	
3	20·00	—	14·25	14·25	14·25	14·25	—
4	17·60	—	12·50	12·50	12·50	12·50	12·28
5	15·80	—	11·10	11·10	11·10	10·00	—
6	14·30	9·00	10·00	10·00	10·00	9·00	10·00
7	13·00	8·13	9·00	9·00	9·00	8·33	9·03
8	11·20	7·26	8·33	8·33	7·70	7·14	8·06
9	9·80	6·40	7·70	7·14	6·66	6·25	7·10
12	7·50	5·65	5·50	5·30	5·00	4·40	6·25

PLASTERER

Plasterer output in square yards per plasterer per hour

Type of work	*Sq. yards per plasterer per hour*
Render and set in lime mortar and hair	3·00
„ float and set with fine material	2·50
Sirapite on cement backing	2·00
Keene's cement on cement backing	2·00
Render in cement mortar on brick walls ½″ thick	2·50
” ” ” ” ” ” ” 1″ ”	2·00

ROAD AND PATH MAKER

Labour output per unit per labourer or tradesman per hour

	Nature of work	*Unit*	*Output per unit per tradesman or labourer per hour*
Roads	Lay clinker	*cu. yd.*	1·50
	„ hardcore	”	1·10
	„ macadam—water-bound	”	1·10
	„ tarmac	*ton*	1·25
	„ concrete roads using 10/7 mixer and barrows	*cu. yd.*	0·30
	” ” ” ” 10/7 „ „ lorries	”	0·44
	” ” ” ” 14/10 „ „ lorries	”	0·48
Paths	„ clinker	”	1·20
	„ crazy paving	*sq. yd.*	1·40
	„ 2″ gravel paving	”	6·00
	„ 1″ granolithic paving	”	2·50
	„ 2″ stone paving—concrete slabs	”	4·00
	” 2½″ ” ” ” ”	”	3·00
	„ 2″ tarmac paving	”	2·66
	„ 2½″ „ ”	”	2·50
	„ 9″ × 9″ tile paving	”	1·66

PAINTER

Painter output in square yards per painter per hour

Type of work		*Square yards per painter per hour*
Creosoting	one coat	4·00
Distempering	,,	10·00
Painting steel joists	,,	1·45
,, woodwork	,,	5·00
Staining	,,	6·00
Varnish	,,	2·50
Paint with pressure-spraying plant	,, oil paint	30·00
Paint with pressure-spraying plant	,, camouflage oil paint	40·00

CONCRETOR

Number of men in gang required, mixing and placing concrete only, using different sizes of mixers of the drum and hopper type. Mixers loaded by hand.

Note.—(1) This table is exclusive of the mixer driver but includes all labour on cement, feeding the mixer and placing the concrete in the work. The table assumes that all concrete is transported by lorry or dumper. If hand wheeling in barrows is carried out, the labourers wheeling away must be added to the number of labourers shown in the table. Barrowing up to a 75 foot run, this would mean adding two labourers in the case of the 5/3½ mixer and three in the case of the 7/5, four in the 10/7 and five in the 14/10.

(2) The labour shown is exclusive of men on screeds in the case of concrete roads, floors, and areas.

Class of work to be concreted	*Number of labourers required mixing and placing the concrete only and exclusive of mixer driver*			
	5/3½	7/5	10/7	14/10
Concrete to beam, braces and columns up to 1 sq. ft. in area	4	5	–	–
,, ,, ,, ,, ,, ,, 1–2 ,, ,,	4	5	6	–
,, ,, ,, ,, ,, ,, 2–3 ,, ,,	4	5	6	–
,, foundations of small area and cross section	4	5	6	–
,, ,, ,, large ,, ,, ,, ,,	–	–	7	8
,, floors and small areas	4	5	6	–
,, roads	–	5	7	8
,, roofs	5	6	7	8
,, pipe haunchings and surrounds up to 18″ dia.	4	5	6	–
,, ,, ,, ,, ,, over 18″ ,,	–	–	7	9
,, fill in tunnels of small C.S. area	5	6	7	–
,, ,, ,, large ,,	–	–	8	9
,, walls 6″ thick	5	6	7	–
,, ,, 9″ ,,	–	6	7	8
,, ,, 12″ ,,	–	6	7	8
,, ,, over 12″ thick	–	6	7	8

Note.—Cases in the above table, where no men are shown indicate that the mixer in question would be uneconomical to use due to the class of work and volume of concrete. The table therefore indicates what size of machine to use on various types of work as well as the number of men to use to construct the work at competitive cost.

CARPENTER

Table showing number of labourers required per carpenter in constructing various work

Type of work	*No. of carpenters*	*No. of labourers*	*Type of work*	*No. of carpenters*	*No. of labourers*
Fix architraves ..	1	1	Fix rafters	2	1
„ barge boards ..	2	1	„ „ hip valley	2	1
„ battens	1	1	„ ridge boards ..	2	1
„ ceiling boards ..	2	1	„ roof boarding ..	2	1
„ „ joists ..	2	1	„ shuttering to beams	1	1
„ cleats to purlins	1	1	„ „ braces	1	1
„ collars	1	1	„ „ columns	1	1
„ cornices	1	1	„ „ floors	1	2
„ fascias	1	1	„ „ joists	1	1
„ floorboards ..	2	1	„ „ roofs	1	2
„ grounds	1	1	„ „ walls	1	2
„ gutter boards ..	1	1	„ skirtings ..	1	1
„ mouldings ..	1	1	„ strutting ..	1	1
„ purlins	2	1	„ wall plates ..	2	1

UNLOADING AND STACKING MATERIALS

Labour output per labourer per unit per hour

Materials unloaded and stacked	*Unit*	*Output per labourer per unit per hour*
Bricks	Number ..	330
Cement	Tons ..	1·00
Reinft. bars ..	Cwts. ..	0·20

LABOUR

LABOUR REQUIRED PER TRADESMAN TO CONSTRUCT VARIOUS WORKS, AND LABOUR APPORTIONMENT TO PLANT IN CONSTRUCTING WORKS WITH DIFFERENT TYPES AND SIZES OF PLANT

BRICKLAYER

Number of labourers required with bricklayers in constructing different classes of work

Item	*Brick-layers*	*Labourers*
To small chambers, manholes, etc.	1	1
To large chambers below ground	2	1
To walls, buildings, etc., above ground	3	2

Rendering in Cement Mortar

Item	*Brick-layers*	*Labourers*
To floors, walls, roofs ..	1	1

MASON

Number of labourers to masons in constructing walls

Type of walls	*Masons*	*Labourers*
Random rubble ..	2	3
Ashlar	1	1

PILEDRIVER

Number of men required in gang, exclusive of man on winch or hammer control

	Pile frame No.	*Man on hammer or winch*	*Total No. men, handle pitch and drive*
Concrete piles	1	1	10
Pitch-pine piles	1	1	8
Sheet piles	1	1	6

CONCRETOR

Number of men in gang required in mixing and placing the concrete in the work only. Using drum and hopper type mixers loaded b machines such as Hi-lift shovel, dragline or grab.

Note.—(1) Table assumes that all concrete is transported by lorries or other means.

(2) The labour shown is exclusive of mixer driver and men on side screeds.

Labour exclusive of plant drivers	*Size of mixer, type of work and number of men*					
	10/7		14/10		21/14	
	Areas	*Foundations*	*Areas*	*Foundations*	*Areas*	*Foundations*
	By machine		*By machine*		*By machine*	
Ganger	1	1	1	1	1	1
Men on cement and water	1	1	2	2	2	2
„ loading mixer and attending on plant	1	1	1	1	1	1
„ placing concrete	1	2	1	2	2	3
„ tamping concrete	2	–	2	-	2	–
„ bullnosing edges	1	–	1	–	1	–
Total number of men including ganger	7	5	8	6	9	7

Number of Men in Gang required in Mixing and Placing Concrete in Areas using Mixing Plant of Various Types and Sizes.

Note.—(1) Loading is carried out by Dragline or Grab and the concrete is transported by lorries, dumpers, etc.

(2) The labour shown is exclusive of the men on side forms and plant drivers.

Labour exclusive of plant drivers	*Type of mixing plant and number of men*						
	32/21	42/28	84/56	*Benford Regulus*		*Multifoote Paver*	
				D.E.13	B.R.25	14 R.	27 E.
Ganger	1	1	1	1	1	1	1
Men on cement and water	3	4	5	3	5	3	5
„ attending on plant	2	2	3	2	3	2	3
„ placing concrete	2	2	3	2	3	2	3
„ tamping concrete	4	4	6	4	6	4	6
„ bullnosing edges and placing expansion joints	2	2	3	2	3	2	3
Total No. of men including ganger	14	15	21	14	21	14	21

EXCAVATOR

Excavator Above Ground

Number of men required excavating by hand and by machine per cart, lorry, etc.

Method of carrying out excavation	*No. men dig and load or with mech. excavator*	*No. men trimming bottom of excavation*	*No. men at tip muck tipped over a bank*	*No. men on points shunting*	*Total number of men*
By hand loaded into carts	2	–	1	–	3
” ” ” 2 ton lorries . .	2	–	1	–	3
” ” ” 3 ” ” . .	3	–	1	–	4
” ” ” 4 ” ” . .	3	–	1	–	4
” ” ” 5 ” ” . .	3	–	1	–	4
” ” ” 2 cu. yd. dumpers. .	2	–	1	–	3
” ” ” 3 ” ” . .	2	–	1	–	3
” ” ” Decauville skips . .	2	–	1	–	3
By mech. excavators loaded into lorries	1	2	1	–	4
” ” ” ” dumpers	1	2	1	–	4
” ” ” Decauville skips	1	2	1	1	5
” ” ” 4′ 8½″ Track wagons	1	2	2	1	6

Note.—(1) The above number of men is exclusive of plant drivers and ganger.

(2) Men at tip usually attend to points and shunting. If muck has to be spread and levelled and not simply tipped over a bank face more labour at the tip would be necessary, depending on area to be covered per cubic yard. (See "Labour Output, Spreading and Levelling," page 60.)

(3) In hand excavation the drivers of the carts, lorries and dumpers should help to load.

CHAMBERS

Excavator Below Ground

Number of men required and labourers per timberman

Class of work	*Timbermen*	*Timbermen's labourers*	*Labourers*	*Total No. men*
Manholes and small pits	1	–	1	2
Basements and large excavations	2	2	4	8

Note.—In connection with basements or large chambers the labour may alter, depending on area and depth, and whether cranes and skips be used, or excavation staged to the surface. In this class of work, however, it is usual for each timberman to have one labourer in attendance.

TRENCH EXCAVATION *by Mechanical Excavators*

Number of men required in gang exclusive of digger driver

Class of ground	*Mechanical excavator*	*Timbermen*	*Timbermen's labourer*	*Labour bottom up*	*Labour refill*	*Total No. men*
Good ground suitable for mechanical excavators	1	1	1	6	8	16

Note.—If ground somewhat loose, depth over 6 feet, or weather wet, 2 timbermen and 1 timberman's labourer may be necessary as walings and spaced runners might have to be put in.

Trench and Tunnel Excavation by Hand

Both of the following tables show the various types of labour required for trench and tunnel excavation and also the number of men required for each gang.

TRENCH EXCAVATION

Number of men required in gang exclusive of compressor drivers

Class of ground	*Timbermen*	*Timbermen's labourers*	*Labourers excavating*	*Labourers refilling*	*Compressor driver*	*Men on pneumatic picks*	*Total No. men*
Good ground such as clay, loam, etc.	2	1	14	5	–	–	22
Friable rock . .	–	–	12	3	1	3	18
Solid rock, sandstone	–	–	4	2	2	6	12
Wet ground, ballast and water . .	2	1	14	4	–	–	21
Wet ground, sand and water . .	2	1	13	3	–	–	19

TUNNEL EXCAVATION

Number of men required in gang

Note.—One crane works two tunnel faces from one shaft. Labour shown is per tunnel face.

Dry ground such as clay, chalk, etc.	*Miners*	*Banksmen*	*Labourers*	*Total No. men*
Small working face, 1 miner	1	1	2	4
Working face over 5 feet wide	2	1	3	6

PIPELAYER

Asbestos Cement Pipes

The labour to use in laying and jointing the pipes

Note.—With this class of pipe the jointer usually assists in the laying of the pipes as well. The laying and jointing table is therefore embodied in one table.

Dia. of pipe in inches	*Lay and joint the pipes*		
	No. of pipelayers	*No. of jointers*	*No. of labourers*
3	1	1	1
4	1	1	1
5	1	1	1
6	1	1	2
7	1	1	2
8	1	1	2
9	1	1	2
10	1	1	2
11	1	1	3
12	1	1	3

PIPELAYER

Cast Iron Pipes

The labour to use in laying and jointing the pipes

	Laying pipes		*Making joints by hand*		*Making joints with pneumatic tools*	
Dia. of pipe in inches	*No. of pipelayers*	*No. of labourers*	*No. of jointers & knockers-up*	*No. of Labourers*	*No. of jointers & knockers-up*	*No. of labourers*
3	1	2	2	1	–	–
4	1	2	2	1	–	–
5	1	2	2	1	–	–
6	1	3	2	1	–	–
7	1	3	2	1	–	–
8	1	3	2	1	–	–
9	1	3	2	1	3	1
12	1	4	3	1	3	1
15	1	4	3	1	3	1
18	1	4	3	1	3	1
21	1	4	3	1	3	1
24	1	4	3	1	3	1
27	1	4	3	1	3	1
30	1	5	3	1	3	1
33	1	5	3	1	3	1
36	1	5	3	1	3	1
42	1	6	3	1	3	1
48	1	6	3	1	3	1

Note.—Jointers and knockers-up include one jointer running the joints, the others knocking up.

Stoneware Pipes or Concrete Tubes

The labour to use in laying and jointing the pipes

	Laying pipes		*Jointing pipes*	
Dia. of pipe in inches	*No. of pipelayers*	*No. of labourers*	*No. of jointers*	*No. of labourers*
4	1	1	1	1
6	1	1	1	1
9	1	1	1	1
12	1	2	1	1
15	1	2	2	1
18	1	3	2	1
21	1	3	2	1
24	1	3	2	1
27	1	3	2	1
30	1	4	2	1
33	1	4	2	1
36	1	4	2	1

PLASTERER

Number of labourers per plasterer required

Type of works	*Plasterers*	*Labourers*
Floating or rendering walls or ceilings	1	1
Floating, rendering and setting walls or ceilings	2	1

PLATELAYER

Number of men required in gang

Laying flat bottom rails on wooden or concrete sleepers. 75lb. rails

Platelayers	*Labourers lay bottoming*	*Labourers lay sleepers*	*Labourers lay and pack up rails*	*Total number of men*
1	4	2	8	15

LAYING 12/14 LB. DECAUVILLE TRACK

	Steel sleepers	*Wooden sleepers*
Labourers	3	4

TILER

Number of labourers per tiler required

Type of work	*Tilers*	*Labourers*
Tiling roofs	1	1
Hips, ridges or eaves—cutting and fixing ..	2	1

ROADMAKER

Work to Roads and Paths

Number of men in gang for various deliveries per hour of clinker, ashes, gravel or ballast

Cubic yards of material delivered per hour	*Consolidated depth and number of men in gang required to lay ballast, gravel or clinker*				
	2″	3″	4″	5″	6″
4	3	3	2	2	2
5	4	3	3	3	3
6	5	4	3	3	3
7	6	5	4	4	4
8	7	5	5	4	4
9	7	6	5	5	4
10	8	7	6	5	5

Note.—In the above table the number of men in gang shown does *not* include the roller driver.

Number of men in gang for various deliveries per hour of hardcore

Cu. yds. of material delivered per hour	*Consolidated depth and number of men in gang required to lay hardcore*					
	3″	4″	5″	6″	9″	12″
4	4	4	3	3	3	2
6	6	5	5	4	4	3
8	7	7	7	6	5	4
10	9	9	8	7	6	5
12	11	10	10	9	7	6
14	13	12	11	11	9	7

Note.—In the above table the number of men as shown does *not* include the roller driver.

NUMBER OF MEN IN GANG FOR VARIOUS DELIVERIES PER HOUR OF MACADAM

Cu. yds. of material delivered per hour	*Consolidated depth and number of men in gang required to lay macadam and slurry in hoggin, etc.*		
	2″	3″	4″
3	3	3	2
4	4	4	3
5	5	4	4

Note.—In the above table the number of men as shown does *not* include the roller driver.

NUMBER OF MEN IN GANG FOR VARIOUS DELIVERIES PER HOUR OF TARMACADAM

Tons tarmacadam delivered per hour	*Consolidated depth and number of men in gang required to lay tarmacadam*				
	2″	2½″	3″	3½″	4″
3	4	3	3	3	3
4	5	4	4	4	4
5	6	5	5	5	5
6	7	7	6	6	6
7	8	8	7	7	7

Note.—In the above table the number of men in gang shown does *not* include the roller driver.

APPLY TAR OR BITUMINOUS DRESSING TO ROADS

Swept down and gritted by hand. Tar or emulsion applied by pressure tank of large capacity.

	Roller	*Labourers*
Dressing with hot tar	1	12
,, cold bitumen	1	10

Note.—In the above table the number of men in gang shown does *not* include the roller driver.

KERB LAYING

Number of men required in gang exclusive of mixer driver

Kerb layer No.	*Labourers excavating No.*	*Labourers concreting No.*	*Labourers with kerb layer No.*	*7/5 mixer and driver No.*	*Total number of men*
1	3	4	1	1	9

LAY 2 IN. PAVING SLABS

Number of labourers per pavior required

Pavior	*Labourers*
1	1

SECTION NINE

★

BONUS AS AN INCENTIVE TO HIGHER OUTPUT

Experience has shown that the payment of bonus acts as an incentive to labour to achieve greater output.

This principle of payment by results has been practised in the civil engineering industry for many years with satisfactory results, but it was only in November 1947 that it was officially recognised and adopted by the building industry, which up to this date had insisted upon payment for work done on a time basis. Both industries, therefore, now recognise this system of payment, and although the building industry is of a more complex nature and involves more component operations than the civil engineering industry, suitable and similar bonus systems of payment are applicable to both.

In operating bonus systems it might be thought that an adverse effect on the quality of the work might result, but such is not the case. Unsound work is not a necessary outcome of high output. If a bonus is offered, the labour concerned is naturally prompted to use ingenuity in overcoming delays and to work with more sustained effort. By combining this factor with keen supervision and sound site administration, it is possible to achieve increased output and still maintain a high standard of work.

The output above the normal achieved by labour due to the incentive of bonus varies with the class of work carried out, the increase being greater in the case of straightforward work where a comparatively large amount is involved, such as in bricklaying, pipe-laying, concreting roads, etc. In actual practice it has been found that the increase in output can be as much as 50% above normal, and in special cases even greater outputs may be achieved.

The bonus systems of payment usually operated on building and civil engineering works of construction come under two main categories:

1. Bonus paid on output in excess of a "Basic Output".
2. Work paid for on a "Piecework Basis".

The method of evolving and operating these bonus systems of payment is the subject of this section. Their operation is closely related to "sound" site administration; carefully conceived bonus systems make for increased output, resulting in a saving in the cost of the work. Their operation is, therefore, to be encouraged as they result in mutual good to both the employee and the employer.

The Basic Output

The "Basic Output", i.e. the datum level of output which has to be achieved before bonus becomes payable must necessarily be the basic output on which the estimate was based, otherwise the bonus paid would bear no direct relation to the estimated cost of the work.

Example.—Assuming the estimated cost of 9 in. brickwork in walls, exclusive of pointing and scaffolding, is "built up" in the following manner:

9 *in. Brickwork in Walls per sq. yd.*

Bricklayer	1·60 hours at 2/6 per hour	= 48·00	pence per sq. yd.
Labourer	1·60 hours at 2/- per hour	= 38·60	„
Bricks	96 No. at 1·25 pence each	= 120·00	„
Mortar	0·065 cu. yds. at 40/- per cu. yd.	= 31·40	„
∴ Estimated cost of brickwork		= 238·00	„

It will be noted that the time taken by a bricklayer and attendant labourer to carry out 1 sq. yd. of the brickwork in question is 1·60 hours. The "Basic Labour Hours" per sq. yd. of brickwork and the "Basic Output" of brickwork per bricklayer per hour on which the estimate is based are, therefore, as follows:

"Basic labour hours" per sq. yd. .. = bricklayer 1·60 hours
= labourer 1·60 „
"Basic Output", sq. yds. per hour .. = $\frac{1{\cdot}00}{1{\cdot}60}$ sq. yds.
= 0·63 sq. yds. of brickwork per bricklayer per hour.

In operating a bonus system of payment in this case bonus is therefore payable on output achieved in excess of this amount.

Note.—This principle of paying bonus on output achieved in excess of a basic output applies to both plant and labour; for example, in the case of a trench excavated by a mechanical trench excavator, the basic output of the plant per hour is considered when computing the actual excavation achieved in excess of the basic output for purposes of calculating the bonus payable.

The Computation of the amount of Bonus to pay so as to ensure a Saving in the Cost of the work

In evolving and operating a bonus system of payment, whether bonus is paid on output in excess of a "Basic Output" or the work is paid for on a "Piecework Basis", the underlying principle involved is that bonus is payable on the labour hour saving resulting from output achieved in excess of a normal or "Basic Output".

In computing the amount to pay, two factors have to be taken into consideration:

1. The operation of the system should result in an effective saving in the cost of the work.
2. The amount of bonus or the piecework rate paid must be such that it offers a real incentive to labour to achieve output in excess of the normal by ensuring them a just reward for their additional efforts.

Referring to the example shown in connection with brickwork above, it will be noted that the "Basic Output" is 0·63 sq. yd. of brickwork per bricklayer per hour, the "basic labour hours" per sq. yd. being: bricklayer 1·60 hours, labourer 1·60 hours. Bonus is therefore payable on output in excess of 0·63 sq. yd. per hour. This bonus is, however, not credited at the full basic labour hours, i.e. 1·60 hours, but only at a percentage of them, thus ensuring that a labour saving is effected in the cost of the work. The problem is, therefore, to decide what this percentage should be, bearing in mind that it must be sufficient to induce labour to achieve output in excess of the normal.

Experience has shown that this percentage should be in the region of 60%, the remainder contributing to a saving in the cost of the work.

This value of 60% should be looked upon as a minimum, but should not be varied to any great extent, so as to ensure a reasonable degree of uniformity in the scale and amount of bonus paid throughout the industries concerned. In the case of the brickwork mentioned, assuming the percentage is taken as being 60%, the bonus payable on output in excess of the "Basic Output" would be: 60% of the "basic labour hours" per sq. yd., i.e.:

Bricklayer 60% of 1·60 hours = 0·96 hour.
Labourer 60% of 1·60 hours = 0·96 hour.

Note.—In paying labour 60% of the labour hour saving resulting from the output achieved in excess of the "Basic Output" it might be thought that a labour hour saving of 40% is obtained by the contractor. This is not strictly correct, as any cost incurred in operating the scheme has to be offset against it. This cost, however, is not considerable, and in some cases may be very small as the work entailed in operating the scheme is often carried out in conjunction with their other duties by staff already on the site. The contractor, though not benefiting by the whole of the 40%, does therefore obtain an effective saving in the cost of the work which is reflected in any profit obtained.

The Distribution of Bonus Payments or Piecework Earnings throughout the Gang

Having computed the bonus or piecework earnings of a gang the amount involved has to be distributed throughout the gang. This is best done by apportioning it on a "share basis" in proportion, or in approximate proportion, to the hourly wage rates of those concerned, and in direct proportion to the hours worked by each, thus:

Classification	*Hourly Wage Rate*	*Share Basis*
Ganger	3/4	1·66
Bricklayer	2/8	1·33
Pipelayer	2/6	1·25
Timberman	2/3	1·13
Labourer	2/-	1·00

Having computed the amount due to each classification in a "lump sum" amount, this sum is then apportioned in direct proportion to the hours worked.

The method of distributing bonus and piecework earnings on this basis is illustrated by example later in this section in connection with bonus systems of payment where bonus is paid on outputs in excess of a "Basic Output" and work paid for on a "Piecework Basis".

The Measurement of the Work Done

The payment of bonus on output in excess of a basic output and work paid for as piecework is invariably carried out on a weekly basis. This involves the measurement of the work done under the various operations, and if a weekly system is in operation this would necessarily have to be done every week. The measurement of the work is carried out by the engineer or surveyor concerned.

The measurements are computed as actual quantities, i.e. cubic yards, square yards, lineal yards, etc., as the case may be, the quantities being best recorded on a "Weekly Measurement Sheet" a typical example of which is shown below. The measurement sheet records:

1. The quantity of work carried out for the current week.
2. The quantity of work previously carried out.
3. The progressive quantity of work carried out to date.

TYPICAL WEEKLY MEASUREMENT SHEET

WEEKLY MEASUREMENT SHEET

Ganger: Smith, J. *Contract:* Lenden. *Week ending* 6/9/49.

Operation	*Unit*	*Week's Quantity*	*Previous Quantity*	*Quantity to date*
Excavate trench for 6 in. dia. water main 3 ft. 6 in. deep..	lin. yds.	625	285	910
9 in. brickwork in walls ..	sq. yds.	133	620	753
etc., etc.				

The tabulation of the work in this manner is a simple method of recording the figures, in which current and progressive quantities to date are always available.

Note.—If a weekly costing system is in operation on the contract in question, the work would necessarily have to be measured up in this connection, so that no additional expense would be incurred in operating the bonus system of payment so far as measuring up the work is concerned.

The Plant and Labour Allocation

In operating these bonus schemes of payment the plant and labour hours expended on the work have to be allocated and recorded, and assuming that they are operated on a weekly basis this allocation must be carried out each week. The allocation is generally performed by the ganger or charge hand concerned, they obviously being in the best position to do so. It will be appreciated that great care must be exercised in carrying out this allocation, and it should be carefully checked by the engineer or surveyor concerned as the work proceeds.

The allocation of the plant and labour hours is best recorded on a "Daily Plant and Labour Allocation Sheet", these hours being abstracted at the end of the current week and recorded on a "Weekly Plant and Labour Allocation Sheet".

A typical "Weekly Plant and Labour Allocation Sheet" is shown below, the "Daily Plant and Labour Allocation Sheet" being similar, except that the word Daily is substituted for the word Weekly.

In order to illustrate the method of operating bonus systems of payment where bonus is payable on output in excess of a "Basic Output", or work is paid for on a "Piecework Basis", each system is dealt with in detail and illustrated by example, the examples being based on the data shown in the "Weekly Measurement Sheet" and "Weekly Plant and Labour Allocation Sheet".

TYPICAL WEEKLY PLANT AND LABOUR ALLOCATION SHEET

WEEKLY PLANT AND LABOUR ALLOCATION SHEET

Ganger: Smith, J. *Contract:* Lendon. *Week ending* 6/9/49.

Operation	*Plant hours*						*Labour hours*						*Remarks*
	Allen 12/21 Trench Excaa tor Machine No. 5						Bricklayer hours.	Labourer hours.					
Excavate, refill and ram trench for 6 in. dia. water main 3 ft. 6 in. deep	40						—	560					Piecework
9 in. brickwork in walls	—						160	160					Piecework
etc., etc.													

Bonus Paid on Output in Excess of a "Basic Output"

In operating this system, the bonus payable per unit in excess of the "Basic Output" is a percentage of the "basic labour hours". As has been shown on p. 72, this percentage should approximate 60% and should not deviate from this to any great extent.

The following table and graph illustrate this system, the labour hours payable as bonus for the range shown being 60% of the "basic labour hours".

Note.—The labour hours payable as bonus on outputs in excess of the "Basic Output" are 60% of the "basic labour hours", the other 40% contributing to a saving in the cost of the work.

The manner in which this system is operated is best illustrated by example, and for this purpose the data shown in the "Weekly Measurement Sheet" and "Weekly Plant and Labour Allocation Sheet" on pp. 73 and 74, relating to the excavation of a trench for a 6 in. diameter water main and 9 in. brickwork in walls are used.

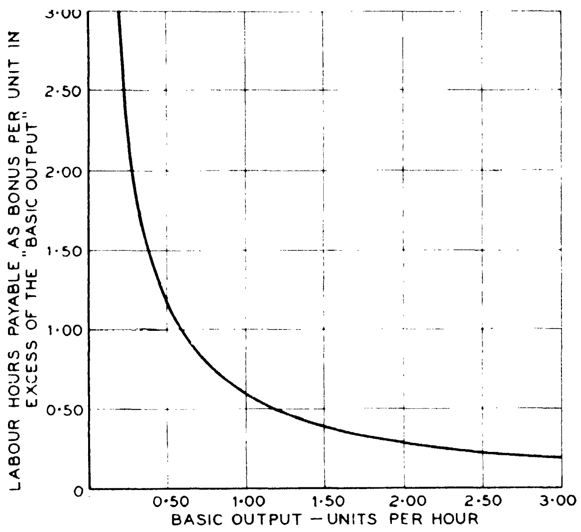


FIG. 3.—GRAPH SHOWING THE LABOUR HOURS PAYABLE AS BONUS PER UNIT ON OUTPUTS IN EXCESS OF "BASIC OUTPUTS" OF VARIOUS AMOUNTS

Note.—This graph is based on the bonus payable being 60% of the "basic labour hours" per unit.

TABLE SHOWING THE LABOUR HOURS PAYABLE AS BONUS ON OUTPUTS IN EXCESS OF THE "BASIC OUTPUT" FOR VARIOUS "BASIC OUTPUTS" PER HOUR

Basic output Units per hour	*Basic hours per unit*	*Labour hours payable as bonus on outputs in excess of the "Basic Output" Labour hours per unit*
0·25	4·00	2·40
0·50	2·00	1·20
0·75	1·33	0·80
1·00	1·00	0·60
1·25	0·80	0·48
1·50	0·66	0·40
1·75	0·57	0·34
2·00	0·50	0·30
2·25	0·44	0·26
2·50	0·40	0·24
2·75	0·36	0·22
3·00	0·33	0·20

The data shown in those sheets are best abstracted and recorded on a "Weekly Bonus Sheet", a separate sheet being kept for each operation.

Typical weekly bonus sheets relating to the excavation of the trench and the 9 in. brickwork concerned are shown below and on p. 77; they contain all the necessary data from which to compute the bonus payable.

By considering the examples shown in conjunction with those weekly bonus sheets no difficulty should be experienced in grasping the essentials involved in operating this system.

Example No. 1.—*Excavate, refill and ram trench for a* 6 *in. diameter water main* 3 *ft.* 6 *in. deep, the excavation being carried out by a* 12/21 *Allen excavator.*

For purposes of this example the following are assumed:

(*a*) Ganger's rate of pay .. .. = 3/4 per hour
(*b*) Plant driver's rate of pay .. .. = 2/8 ,,
(*c*) Labourer's rate of pay .. .. = 2/- ,,
(*d*) Bonus payable 60% of the labour hour saving resulting from output in excess of the "Basic Output".

Referring to the "Weekly Bonus Sheet" shown on p. 77, the total bonus earned by the gang for the week is as follows:

TYPICAL WEEKLY BONUS SHEET INVOLVING PLANT AND LABOUR

Note.—(1) The relevant data shown are abstracted from the "Weekly Measurement Sheet" and "Weekly Plant and Labour Allocation Sheet" shown on pp. 73 and 74.
(2) Labour is credited with 60% of the labour hour saving resulting from output in excess of the "Basic Output".

WEEKLY BONUS SHEET

Ganger: G. Fraser. *Contract:* Lenden. *Week ending* 6/9/49.

Operation	Excavate, refill and ram trench for 6 in. dia. water main 3 ft. 6 in. deep
Plant employed	Allen 12/21 trench excavator
Complement of gang ..	1 No. ganger, 1 No. plant driver, 14 No. labourers
Plant hours worked for the week	40
Plant "Basic Output" lin. yds. per hour	11·75
Plant "Basic Hours" per lin. yd.	0·086
Labour "Basic Hours" per lin. yd.	1·20

Item	*Unit*	*Quantity*
Trench work for the week	lin. yds.	625
"Basic Output" of trench for the week (40 hours × 11·75 lin. yds.)	,,	470
Output in excess of the "Basic Output" (625–470) lin. yds.	,,	155
Credit as bonus per lin. yd.		
Plant driver: 60% of 0·086 hours ..	Hours	0·052
Labourer: 60% of 1·20 hours ..	,,	0·72
Total bonus earned:		
Plant driver: 155 lin. yds. × 0·052 hours	,,	8
Labourers: 155 lin. yds. × 0·72 hours	,,	112

Plant driver, 8 hours at 2/8 .. = £ 1 1 4
Labourers, 112 hours at 2/– .. = £11 4 0
£12 5 4

The ratio of ganger's, plant driver's and labourer's rate of pay per hour is as follows:

3/4 : 2/8 : 2/- :
1·67 : 1·33 : 1·00

The gang consists of 1 No. ganger, 1 No. plant driver and 14 No. labourers, therefore:

Ganger receives 1 × 1·67 shares .. .. = 1·67 shares
Plant driver receives 1 × 1·33 shares .. = 1·33 „
Labourers receive 14 × 1·00 shares .. = 14·00 „
Total 17·00

$$\therefore \text{ Ganger receives } \frac{1\cdot67}{17} \times £12\ 5\ 4 = 24/\text{–}$$

$$\text{Plant driver receives } \frac{1\cdot33}{17} \times £12\ 5\ 4 = 19/8$$

$$\text{Each labourer receives } \frac{1\cdot00}{17} \times £12\ 5\ 4 = 14/5$$

TYPICAL WEEKLY BONUS SHEET INVOLVING LABOUR ONLY

Note.—(1) The relevant data shown are abstracted from the "Weekly Measurement Sheet" and "Weekly Plant and Labour Allocation Sheet" shown on pp. 73 and 74.

(2) Labour is credited with 60% of the labour hour saving resulting from output in excess of the "Basic Output".

WEEKLY BONUS SHEET

Charge hand: J. Smith. *Contract:* Lenden. *Week* ending 6/9/49.

Operation	9 in. brickwork in walls
Complement of gang	1 No. charge hand, 4 No. bricklayers, 4 No. labourers
Bricklayer hours for the week ..	160
Labourer hours for the week ..	160
"Basic Output" sq. yds. per bricklayer per hour	0·63
"Basic labour hours" per sq. yd.:	
Bricklayer	1·60
Labourer	1·60

Item	*Unit*	*Quantity*
Quantity of brickwork for the week ..	Sq. yds.	133
"Basic Output" of brickwork for the week (160 hours × 0·63 sq. yds.)	„	100
Output in excess of the basic output (133–100) sq. yds.	„	33
Credit as bonus per sq. yd.:		
Bricklayer: 60% of 1·60 hours	Hours	0·96
Labourer: 60% of 1·60 hours	„	0·96
∴ Total bonus earned:		
Bricklayers: 33 sq. yds. × 0·96 hours ..	„	32
Labourers: 33 sq. yds. × 0·96 hours ..	„	32

i.e. Ganger	1 No. at 24/-	=	£1 4 0
Plant driver	1 No. at 19/8	=	£0 19 8
Labourers	14 No. at 14/5	=	£10 1 8
			£12 5 4

Note.—In the example shown it is assumed that the ganger, plant driver and the labour concerned each work the same number of hours for the week.

Assuming, however, that a forty-hour week is in operation and the actual hours worked are as follows:

Ganger	40 hours
Plant driver	40 „
4 No. labourers	42 „
8 No. labourers	40 „
2 No. labourers	36 „

the ganger and plant driver would receive the bonus amounts shown, viz.: 24*s.* and 19*s.* 8*d.* each, but the total bonus due to labour, i.e. £10 1*s.* 8*d.*, would be apportioned in the following manner:

4 labourers	42 hours	=	168 hours
8 labourers	40 „	=	320 „
2 labourers	36 „	=	72 „
	Total	=	560 „

The bonus payable is then apportioned in accordance with the hours worked thus:

$$\frac{42}{560}\times £10\ \ 1\ \ 8 = 15/3$$

$$\frac{40}{560}\times £10\ \ 1\ \ 8 = 14/4$$

$$\frac{36}{560}\times £10\ \ 1\ \ 8 = 13/-$$

i.e. 4 labourers at 15/3	=	£3 1 0
8 labourers at 14/4	=	£5 14 8
2 labourers at 13/-	=	£1 6 0
		£10 1 8

Example No. 2.—9 in. Brickwork in Walls

For the purposes of this example the following are assumed:

(*a*) Charge hand's rate of pay .. .. = 3/4 per hour
(*b*) Bricklayer's rate of pay .. .. = 2/8 „
(*c*) Labourer's rate of pay .. .. = 2/- „
(*d*) Bonus payable 60% of the labour hour saving resulting from output in excess of the "Basic Output".

Referring to the "Weekly Bonus Sheet" shown on p. 77, the total bonus earned by the gang for the week is as follows:

Bricklayers	32 hours at 2/8	=	£4 5 4
Labourers	32 hours at 2/-	=	£3 4 0
			£7 9 4

The ratio of charge hand's, bricklayer's and labourer's rate of pay per hour is as follows:

3/4 : 2/6 : 2/-
1·67 : 1·33 : 1·00.

The gang consists of 1 No. charge hand, 4 No. bricklayers and 4 No. labourers, therefore:

Charge hand receives	1 × 1·67 shares	.. .. ..	=	1·67 shares
Bricklayers receive	4 × 1·33 „	.. .. ..	=	5·33 „
Labourers receive	4 × 1·00 „	.. .. ..	=	4·00 „
		Total ..	=	11·00

∴ Charge hand receives $\frac{1\cdot67}{11}\times$ £7 9 4 = 23/4

Each bricklayer receives $\frac{1\cdot33}{11}\times$ £7 9 4 = 18/–

Each labourer receives $\frac{1\cdot00}{11}\times$ £7 9 4 = 13/6

i.e. Charge hand	1 No. at 23/4	.. ..	=	£1 3 4
Bricklayers	4 No. at 18/–	.. ..	=	£3 12 0
Labourers	4 No. at 13/6	.. ..	=	£2 14 0
				£7 9 4

Note.—In the example shown it is assumed that the charge hand, bricklayers and labourers work the number of hours for the week.

Assuming, however, that a forty-hour week is in operation and the actual hours worked are as follows:

Charge hand	40 hours
4 No. bricklayers	40 hours each
1 No. labourer	44 hours
1 No. „	42 „
1 No. „	40 „
1 No. „	34 „

the charge hand and bricklayers receive the bonus amounts shown, i.e. charge hand 23*s*. 4*d* and bricklayers 18*s*. each. The total bonus due to the labourers, however, i.e. £2 14*s*., is apportioned in the following manner:

1 No. labourer	44 hours	.. ..	=	44 hours
1 No. „	42 „	.. ..	=	42 „
1 No. „	40 „	.. ..	=	40 „
1 No. „	34 „	.. ..	=	34 „
		Total ..	=	160 „

The bonus paid is then apportioned in accordance with the hours worked, thus:

$\frac{44}{160}\times$ £2 14 0 = £0 14 10

$\frac{42}{160}\times$ £2 14 0 = £0 14 0

$\frac{40}{160}\times$ £2 14 0 = £0 13 6

$\frac{34}{160}\times$ £2 14 0 = £0 11 8

£2 14 0

Work Paid for on a Piecework Basis

In paying for work on a piecework basis the underlying principle involved is similar to that in paying bonus on output in excess of a "Basic Output", viz.:

The labour concerned is credited with a percentage of the labour hour saving resulting from output achieved in excess of a "Basic Output".

This percentage should approximate 60%, as explained in the case of a bonus system where bonus is paid on output in excess of a "Basic Output", and should not deviate from this to any great extent.

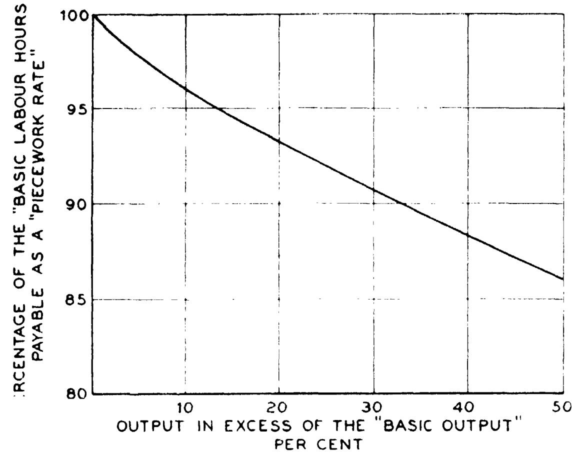


FIG. 4.—GRAPH SHOWING THE PERCENTAGE OF THE "BASIC LABOUR HOURS" PAYABLE AS A "PIECEWORK RATE" FOR VARIOUS PERCENTAGE OUTPUTS IN EXCESS OF THE "BASIC OUTPUT"

Note.—This graph is based on the labour concerned being credited with 60% of the labour hour saving resulting from output achieved in excess of the "basic output".

TABLE SHOWING THE PERCENTAGE OF THE "BASIC HOURS" PAYABLE AS A PIECE-WORK RATE PER UNIT FOR OUTPUTS RANGING FROM 0% TO 50% IN EXCESS OF THE "BASIC OUTPUT"

Note.—(1) The percentages shown are based on labour being credited with 60% of the labour hour saving resulting from output achieved in excess of the "Basic Output".

(2) The percentage of the "basic hours" payable as a "Piecework Rate" as shown in column 8 is the sum of columns 4 and 6

(1) *Basic output per hour* *Units*	(2) *Basic hours* *Per unit*	(3) *Actual output per hour* *Units*	(4) *Actual hours* *Per unit*	(5) *Labour hour saving per unit* *Labour hours*	(6) 60% *of labour hour saving* *Labour hours*	*Piecework*	
						(7) *Output in excess of the "Basic Output"* %	(8) *Percentage of the "Basic Hours" payable as a piecework rate per unit* %
1·00	1·00	1·00	1·00	Nil	Nil	Nil	100
1·00	1·00	1·05	0·95	0·05	0·03	5	98
1·00	1·00	1·10	0·91	0·09	0·05	10	96
1·00	1·00	1·15	0·87	0·13	0·08	15	95
1·00	1·00	1·20	0·83	0·17	0·10	20	93
1·00	1·00	1·25	0·80	0·20	0·12	25	92
1·00	1·00	1·30	0·77	0·23	0·14	30	91
1·00	1·00	1·35	0·74	0·26	0·16	35	90
1·00	1·00	1·40	0·71	0·29	0·17	40	88
1·00	1·00	1·45	0·69	0·31	0·18	45	87
1·00	1·00	1·50	0·66	0·34	0·20	50	86

In paying for work on a piecework basis the work is measured up and paid for at an agreed monetary rate per unit, the labour concerned receiving no other remuneration in the way of ordinary time earnings. The piecework rate is agreed ***prior*** to the work being carried out. This is fundamentally different from the payment of bonus on output achieved in excess of a "Basic Output", in which case the bonus due is computed ***after*** the work has been carried out, the labour receiving payment at their ordinary time rates together with any bonus due.

The practice of paying a fixed piecework rate irrespective of the actual output achieved in excess of the "Basic Output" is commonly adopted, the rate being based on an assumed output.

In paying piecework rates on a sliding scale in this manner the labour is credited with a fixed percentage of the labour hour saving for the actual output achieved, the remainder contributing to an effective saving in the cost of the work.

The computation of the piecework rates payable is best reduced to terms of a percentage of the "basic labour hours" per unit, the percentage depending upon the assumed output on which it is based.

In order to illustrate how these percentages are computed a table and graph are shown on p. 80.

The data shown in the table and graph are based on the labour concerned being credited with 60% of the labour hour saving resulting from output achieved in excess of the "Basic Output", and covers a range of outputs ranging from 0% to 50% in excess of the normal or "Basic Output".

It will be noted that in crediting the labour with 60% of the labour hour saving, the percentage of the "basic labour hours" paid as a "piecework rate" decreases as the output increases.

In order to illustrate the method of computing the scale of piecework rates to pay in connection with a specific operation, the case of a 9 in. wall is considered.

For purposes of this example the following are assumed:

TABLE SHOWING THE SCALE OF PIECEWORK RATES PAYABLE FOR 9 IN. BRICKWORK IN WALLS

Output in excess the "Basic Output" %	*Percentage of the "basic labour hours" payable as a piece-work rate per unit* %	*Piecework rate payable per sq. yd. of brickwork*	
		Bricklayer hours	*Labourer hours*
5	98	1·57	1·57
10	96	1·54	1·54
15	95	1·52	1·52
20	93	1·50	1·50
25	92	1·48	1·48
30	91	1·46	1·46
35	90	1·44	1·44
40	88	1·42	1·42
45	87	1.40	1·40
50	86	1·38	1·38

Note.—(1) The "basic labour hours" per sq. yd. of brickwork on which the data are based are: Bricklayer 1·60 hours; labourer 1·60 hours.

(2) The labour concerned is credited with 60% of the labour hour saving resulting from output achieved in excess of the "Basic Output", e.g. output in excess of "Basic Output" 35%, hours payable as a piecework rate: Bricklayer 90% of 1·60 hours = 1·44 hours; labourer 90% of 1·60 hours = 1·44 hours.

1. "Basic Output" on which the estimate is based is 0·63 sq. yd. of brickwork per bricklayer per hour.
2. "Basic labour hours" per sq. yd. of brickwork on which the estimate is based are:
   Bricklayer 1·60 hours.
   Labourer 1·60 hours.
3. In computing the piecework rates the labour concerned is credited with 60% of the labour hour saving resulting from output in excess of the "Basic Output".

In the table on p. 80 the method of computing the percentage of the "basic labour hours" payable as a piecework rate is shown. The percentages shown are based on labour being credited with 60% of the labour hour saving achieved, and they are therefore applicable to this example.

The piecework rates payable for the brickwork in question, for outputs ranging from 0% to 50% in excess of the "Basic Output", are therefore as shown in the table on p. 81.

Referring to this table and assuming that the piecework rate is based on an output of 35% in excess of the "Basic Output", the bricklayer's and labourer's rate of pay per hour being 2*s*. 6*d*. and 2*s*. respectively, the piecework rate payable per sq. yd. of brickwork is:

90% of the "basic labour hours".
i.e. 90% of 1·60 hours = 1·44 hours.

The piecework rate payable per sq. yd. of brickwork is therefore:

Bricklayer 1·44 hours at 2/6 per hour .. .. .. = 43·20 pence per sq. yd.
Labourer 1·44 hours at 2/- per hour .. .. .. = 34·56 ,,
∴ Piecework rate payable .. .. = 77·76 ,,

Say 6/6 per sq. yd.

Note.—The basic labour cost per sq. yd. of brickwork on which the estimate is produced is:

Bricklayer 1·60 hours at 2/6 per hour .. .. .. = 48·00 pence per sq. yd.
Labourer 1·60 hours at 2/- per hour .. .. . = 38·40 ,,
∴ Basic labour rate on which estimate is based .. = 86·40 ,,

Say 7/3 per sq. yd.

The contribution to the saving in the cost of the work, therefore, is 7*s*. 3*d*. − 6*s*. 6*d*. = 9*d*. per sq. yd., any cost incurred in operating the system being offset against this.

The work having been measured up and the total piecework earnings of the gang computed, the whole is then distributed throughout the gang on a share basis in the manner previously shown.

SECTION TEN

BRICKLAYER

The tables shown for brickwork are based on the three standard sizes of bricks:

$8\frac{3}{4} \times 4\frac{3}{16} \times 2$ in.
$8\frac{3}{4} \times 4\frac{3}{16} \times 2\frac{5}{8}$ in.
$8\frac{3}{4} \times 4\frac{3}{16} \times 2\frac{7}{8}$ in.

The data are based on the standard thickness of joint of $\frac{3}{8}$ in.

It should be noted that the cost of brickwork depends to a large extent on two factors:

1. The class of work built.
2. The number of bricks laid per bricklayer per hour.

The latter factor can be extremely variable for some bricklayers can lay comfortably 80 to 100 bricks per hour in a specified class of work, while the output of others may be considerably less than this.

In the tables shown for "Stock Brickwork" the number of bricks laid per bricklayer per hour is stated, the data shown for "facings" being based on an output of 40 No. bricks per bricklayer per hour; these figures represent a fair average. The labourer hours shown allow for attendance on the bricklayer and for off-loading and stacking on the site.

If it is assessed that the bricklayer can lay more (or less) bricks per hour than those shown a multiplier may be evolved for use with the bricklayer and labourer hours shown in the tables in the following manner:

Example.—Assuming the table for stock brickwork is based on an output of 60 No. bricks per bricklayer per hour and it is assessed that 80 bricks per hour would be laid by the bricklayer or bricklayers concerned, the bricklayer and labourer hours shown in the tables may be multiplied by $\frac{60}{80}$, i.e. 0·75.

Allowance for Waste

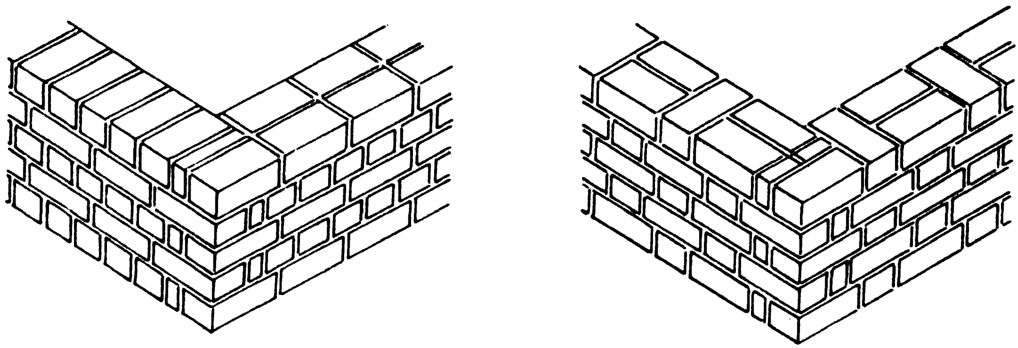
In practice an allowance for waste is unnecessary in the case of bricks of a reasonably strong and hard nature, experience having shown that little or no waste occurs. If the bricks to be used are of a very soft or easily broken nature $2\frac{1}{2}\%$ may be allowed to cover waste and breakage loss.

Mortars for Brickwork

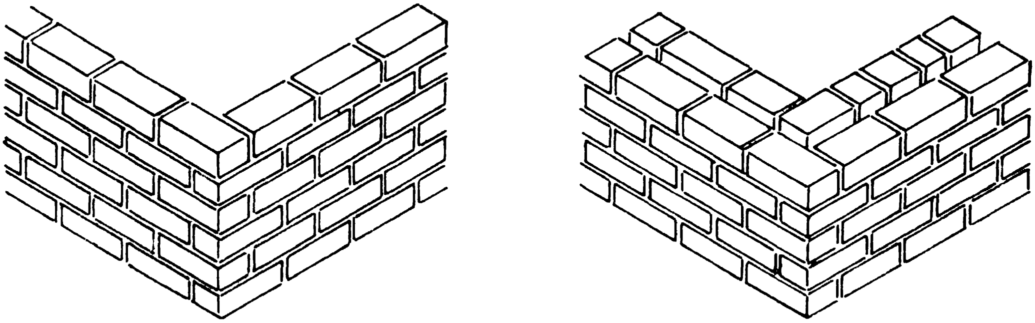
Brickwork is carried out with lime mortar, cement lime mortar and cement mortar, depending on the class of the work and the mortar specified.

Tables are shown setting out the materials required per cubic yard of mortar of various mixes, together with the labour hours taken to "knock up" the mortar by hand. Data are also shown for mixing mortar mechanically in a pan-mill mortar mixer of 4 ft. 6 in. diameter, this plant being commonly used where large volumes of mortar are required.

The estimator should note that the figures shown in the tables for brickwork do not allow for the labour hours expended on "knocking up" the mortar, and this must be allowed for in computing the "all-in" cost of the mortar per cubic yard.



9" ENGLISH BOND 9" FLEMISH BOND



STRETCHER BOND 11" CAVITY WALL

FIG 5.—SOME OF THE BONDS EMPLOYED BY THE BRICKLAYER IN ERECTING BRICKWORK

Scaffolding

In constructing brickwork to height, two factors should be noted:

1. The cost of bricklaying increases with height, since increased cost is involved in getting the bricks and mortar to the bricklayer.
2. Scaffolding has to be erected in order that the bricklayer can carry out the work.

Regarding (1) the data shown in the estimating tables may be used for work carried out to a height of 40 ft. above ground level. In carrying out brickwork to heights in excess of this, multipliers are shown for use with the data shown in the main estimating tables.

Regarding (2) the cost of erecting and dismantling the scaffolding is assessed per sq. yd., and is then allowed for in one or other of the following ways:

1. By adding the cost of scaffolding per sq. yd. of brickwork to the cost of the brickwork itself.
2. Knowing the cost of the scaffolding per sq. yd. and the total sq. yds. of brickwork to be built, by allowing for it on a "lump sum" basis.

Data from which to estimate the cost of erecting and dismantling scaffolding are shown on p. 237.

The estimator should note that the data shown in the tables for brickwork do not allow for the cost of scaffolding, and where such is required this must be allowed for in addition.

It should be noted that the scaffolding is used for trades other than external bricklayer, such as slater, tiler, roof carpenter, painter, external renderer, etc. If the cost of scaffolding is allowed for wholly under bricklayer, no allowance for it need be made under the other trades. Making an allowance under bricklayer is the most simple method, as apportioning the cost to the various trades is almost impossible and would, in any case, only tend to make the estimation of the cost of the work as a whole more complicated.

Any loading and haulage cost involved in connection with the scaffolding should not be overlooked and should also be allowed for.

Stock Brickwork

Brickwork is carried out in half-brick walls, two half-brick hollow walls or 11 in. work, solid 9 in. work, $1\frac{1}{2}$ brick walls or 14 in. work and thicknesses in excess of this.

In connection with the tables shown for stock brickwork it should be noted that the data shown are for laying only and do not include the following:

1. The cost of "knocking up" the mortar.
2. The cost of erecting and dismantling scaffolding and any haulage or hire cost involved.
3. The cost of pointing the brickwork.

The cost of these must be allowed for by including the correct amount from the data shown for mortars on pp. 90 and 91, scaffolding on p. 237, and pointing on p. 98.

Note.—The "rod" as a standard of measurement is not now recognised, but data from which to compute the cost of brickwork on this basis has again been included in this edition in order that those who still prefer to "build up" a price on this basis may have available data from which to do so.

Examples showing the Method of Estimating the Cost of Stock Brickwork.—For purposes of illustration, examples are shown for brickwork carried out with single frogged fletton bricks, $8\frac{3}{4} \times 4\frac{3}{16} \times 2\frac{5}{8}$ in., built in three-to-one lime mortar.

No sum is allowed for the cost of water used in connection with the mortar, it being assumed that all the water required for the contract as a whole has been computed and allowed for as a "lump sum", see p. 16.

The cost of scaffolding is allowed for on a per sq. yd. of brickwork basis, exclusive of any haulage cost or hire rate involved.

The cost of carrying out the pointing to the brickwork is not included. Examples showing the method of estimating the cost of this are shown on pp. 87 and 88.

The examples shown for stock brickwork are based on the following rates:

Bricklayer's rate	2/4 per hour
Scaffolder's rate	2/1 per „
Labourer's rate	2/- per „
Fletton bricks delivered "on the site"	83/4 per 1,000
Grey stone lime delivered "on the site"	65/- per ton
Sand delivered "on the site"	10/- per cu. yd.
Hollow wall ties delivered "on the site"	2*d.* each

By referring to the estimating tables shown for scaffolding, lime mortar, stock brickwork carried out with 3 to 1 lime mortar, and $8\frac{3}{4} \times 4\frac{3}{16} \times 2\frac{5}{8}$-in. bricks, the data shown throughout the various examples are found.

The Cost of 3 *to* 1 *Lime Mortar per cubic yard*

Lime	0·20 tons	at 65/- per ton	=	156·00 pence
Sand	1·10 cu. yds.	at 10/- per cu. yd.	=	132·00 „
Labour mixing ..	5·00 hours	at 2/- per hour	=	120·00 „
∴ Total labour and material cost per cu. yd.			=	408·00 „

Note.—The cost of the water required is taken as being allowed for on the contract as a whole, on a "lump sum" basis.

Example No. 1.—Calculate the cost per sq. yd. of fletton brickwork in a half-brick wall in 3 to 1 lime mortar where no scaffolding is required.

48 No. bricks at 83/4 per 1,000			=	48·00 pence
Mortar	0·024 cu. yd.	at 408·00 pence per cu. yd. ..	=	9·80 „
Bricklayer ..	0·96 hour	at 2/4 per hour	=	26·88 „
Labourer ..	0·96 hour	at 2/- per hour	=	23·04 „
∴ Total labour and material cost per sq. yd., exclusive ofpointing			=	107·72 „
			=	9/- per sq. yd.

Example No. 2.—Calculate the cost per sq. yd. of one brick wall in fletton brickwork in 3 to 1 lime mortar where scaffolding is required; the work not being in excess of 40 ft. in height.

96 No. bricks at 83/4 per 1,000			=	96·00 pence
Mortar	0·06 cu. yd.	at 408·00 pence per cu. yd. ..	=	24·48 „
Bricklayer ..	1·60 hours	at 2/4 per hour	=	44·80 „
Labourer ..	1·60 hours	at 2/- per hour	=	038·40 „
Erect and strike scaffolding: labour 0·62 hour at 2/1			=	15·5 „
∴ Total labour and material cost per sq. yd., exclusive of pointing			=	219·18 „
			=	18/3 per sq. yd.

Example No. 3.—Calculate the cost per sq. yd. of a two half-brick 11 in. hollow wall in fletton brickwork in 3 to 1 lime mortar where scaffolding is required, the work not being in excess of 40 ft. in height, there being 4 No. wall ties required per sq. yd.

96 No. bricks at 83/4 per 1,000		=	96·00 pence
Mortar	0·05 cu. yd. at 408·00 pence per cu. yd. ..	=	20·40 „
Wall ties ..	4 No. at 2*d.* each	=	8·00 „
Bricklayer ..	1·92 hours at 2/4 per hour	=	53·76 „
Labourer ..	1·92 hours at 2/- per hour	=	46·08 „
Fix 4 No. wall ties:			
Bricklayer ..	4 No. × 0·02 = 0·08 hour at 2/4 per hour ..	=	2·24 „
Labourer ..	4 No. × 0·02 = 0·08 hour at 2/- per hour ..	=	1·92 „
Erect and strike scaffolding: labourer 0·62 hour at 2/1 per hour		=	15·50 „
∴ Total labour and material cost per sq. yd., exclusive of pointing		=	243·90 „
		=	20/4 per sq. yd.

Example. No. 4.—Calculate the cost per rod of reduced brickwork in fletton bricks in 3 to 1 lime mortar where scaffolding is required, the work not being in excess of 40 ft. in height.

Note.—1 rod of reduced brickwork = 30·25 sq. yds.
∴ 30·25 sq. yds. of scaffolding must be allowed for per rod of brickwork.

4,300 bricks at 83/4 per 1,000			=	4300·00 pence
Mortar	2·80 cu. yds.	at 408·00 pence per cu. yd. ..	=	1142·40 „
Bricklayer ..	61·43 hours	at 2/4 per hour	=	1720·04 „
Labourer ..	61·43 hours	at 2/- per hour	=	1474·32 „
Erect and strike scaffolding:				
30·25 sq. yds. at 0·62 hour per sq. yd. = 18·75 hours at 2/1 hour			=	468·74 „
∴ Total labour and material cost per rod, exclusive of pointing ..			=	9105·50 „
			=	£37 18 10 per rod.

Pointing Brickwork

Pointing brickwork may be carried out as the work proceeds or as a separate operation. In the former case the joints are "flushed" or "struck" by the bricklayer as the work of bricklaying goes on, while in the latter case the joints are raked out before the mortar has set and the actual pointing carried out as a separate operation after the mortar has set. This latter method is more costly to execute. The actual pointing may be carried out with lime or cement mortars, the aggregates being selected to give different ranges of colour.

A form of pointing which is now commonly used in pointing brick facings is the "ironed" or "rubbed" joint. This method of pointing is carried out as follows:

In laying the bricks the joints are well mortared and struck or flushed with the trowel as the work proceeds. Prior to the mortar in the joint setting it is rubbed or ironed in with a piece of round bar or tubing $\frac{3}{8}$ in. in diameter, slightly bent at the end. By continuous rubbing a very pleasing joint is obtained and it is possible to polish the joints by this means.

Tuck pointing and pointing old work is also dealt with.

In the case of new brickwork carried out at height, the pointing is carried out from scaffolding erected for the purpose of building the brickwork itself. Since the cost of this scaffolding is allowed for in the cost of the brickwork or on a "lump sum" basis, no allowance need be made for it in the cost of the pointing. If, however, pointing has to be carried out to old brickwork, and scaffolding has to be erected and dismantled for the specific purpose of carrying this out, its cost must be allowed for and included in the estimate for the pointing The estimator is referred to p. 237, where data are shown from which the cost of erecting and dismantling scaffolding can be found. Any hire charge and haulage cost in connection with the scaffolding should also be taken into consideration.

To illustrate the method of estimating the cost of pointing brickwork, examples are shown for pointing carried out in English bond with $8\frac{3}{4} \times 4\frac{3}{16} \times 2\frac{5}{8}$ in. bricks.

Examples showing the Method of Estimating the Cost of Pointing Brickwork.—For purposes of the examples shown it is assumed that the pointing is carried out to brickwork in English bond in 3 to 1 lime mortar, the following being the prevailing labour and material rates:

Bricklayer's rate	2/4 per hour
Labourer's rate	2/- „
Lime	65/- per ton, delivered site
Sand	10/- per cu. yd., delivered site

The Cost of 3 to 1 Lime Mortar per cubic yard

From the table shown on p. 91 the cost of 3 to 1 lime mortar is as follows:

Lime .. 0·20 ton at 65/- per ton .. .. = 156·00 pence
Sand .. 1·10 cu. yds. at 11/- per cu. yd. .. = 132·00 „
Labour mixing, 5·00 hours at 2/- per hour .. = 120·00 „
∴ Total labour and material cost per cu. yd. .. = 408·00 „
= 15·11 pence per cu. ft.

Note.—The cost of the water required is taken as being allowed for on the contract as a whole on a "lump sum" basis.

Example No. 1.—Calculate the cost per sq. yd. of raking out and pointing brickwork in English bond with 3 to 1 lime mortar with a neat weathered joint, the bricks used being $8\frac{3}{4} \times 4\frac{3}{16} \times 2\frac{5}{8}$ in.

From the table shown on p. 98 the cost of pointing is given by:

Mortar .. 0·056 cu. ft. at 15·11 pence per cu. ft. = 0·85 pence
Bricklayer .. 0·80 hour at 2/4 per hour .. .. = 22·40 „
Labourer .. 0·80 hour at 2/- per hour .. .. = 19·20 „
∴ Labour and material cost per sq. yd. .. .. = 42·45 „

Example No. 2.—Calculate the cost per sq. yd. of pointing facings in English bond as the work proceeds, the joints being ironed or rubbed with a $\frac{3}{8}$ in. diameter bent steel rod, the bricks used being $8\frac{3}{4} \times 4\frac{3}{16} \times 2\frac{5}{8}$ in., built in 3 to 1 lime mortar.

Note.—(1) No additional mortar has to be inserted in the joints in this form of pointing, the brickwork joints having been fully mortared when laying the bricks. In view of this full mortaring of the joints, however, it is advisable in estimating to allow for the mortar required for pointing as shown in the pointing table.

(2) Referring to the multiplier table on p. 98 it will be seen that for this type of pointing a multiplier of 0·60 is used with the bricklayer and labourer hours shown in the pointing table.

From the pointing table shown also on p. 98 the cost of pointing is given by:

Mortar .. 0·056 cu. ft. at 15·11 pence per cu. ft. = 0·85 pence
Bricklayer .. 0·60 × 0.80 = 0·48 hour at 2/4 per hour = 13·44 „
Labourer .. 0·60 × 0·80 = 0·48 hour at 2/- per hour = 11·52 „
∴ Labour and material cost per sq. yd. .. .. = 25·81 „

Facing Work

Brickwork facings involve additional labour cost as compared with ordinary work, because the facing bricks are selected or hand-picked and the work involved in laying them is of a higher standard.

The facings may be laid to various bonds, those most commonly met with being English and Flemish in 9 in. work, and stretcher bond in 4½ in. work.

The "pointing" of facing bricks is generally included in the item "billed" for facings, but for purposes of estimating, pointing is shown separately in this work so that pointing of various kinds can be allowed for in computing the cost of the facing work.

Facings are invariably billed as "Extra Only" over ordinary brickwork.

This "Extra Only" cost is made up of:

1. The additional cost of the bricks over ordinary bricks.
2. The additional cost of selecting or hand-picking the bricks and laying them in the work.

The calculation of the "Extra Only" cost may be worked out either on the basis of cost per sq. yd. of facings, or per thousand facing bricks. The data shown in the table for brick facings refer to the "Extra Only" hours over ordinary brickwork to lay 1 sq. yd. of facing bricks in the work to the various bonds shown, the hours shown being exclusive of pointing.

To illustrate the method of estimating the "Extra Only" cost of facing work, examples are shown, and in the case of each it is assumed that the work carried out is in English bond.

The cost of pointing is not included, examples showing how to estimate the cost of this being shown on p. 87 and above.

The examples shown are based on the following rates:

Bricklayer's rate	2/4 per hour
Labourer's rate	2/- „
Facing bricks delivered "on the site"	125/- per 1,000
Ordinary bricks delivered "on the site"	83/4 „

Example No. 1.—Calculate the "Extra Only" cost per sq. yd. for hand-picked facings over ordinary brickwork, exclusive of pointing, the bricks used being 8$\frac{3}{4}$ × 4$\frac{3}{16}$ × 2$\frac{5}{8}$ in. and the work carried out in English bond.

Facing bricks delivered "on the site"	125/-	per 1,000
Ordinary bricks delivered "on the site"	83/4	,,
∴ "Extra Only" cost of facing bricks	41/8	,,

Referring to the table shown for brick facings on p. 96, the number of facing bricks required per sq. yd. in English bond is 72 No., and the "Extra Only" bricklayer and labourer hours per sq. yd. for facing work in English bond is 0·60 and 0·96 hours respectively.

∴ The "Extra Only" cost of the facing work over ordinary brickwork per sq. yd. is:

"Extra Only" cost of facing bricks $\frac{72}{1,000} \times 41/8$ ..	= 36·00	pence sq. yd.
Bricklayer 0·60 hour at 2/4 per hour	= 16·80	,,
Labourer 0·96 hour at 2/- per hour	= 23·04	,,
∴ "Extra Only" cost of facing work	= 75·84	,,
	= 6/4	per sq. yd.

Note.—The above is exclusive of pointing.

Example No. 2.—Calculate the "Extra Only" cost per 1,000 facing bricks over ordinary bricks for hand-picking and laying the facings in the work, exclusive of pointing, the facing bricks used being 8$\frac{3}{4}$ × 4$\frac{3}{16}$ × 2$\frac{5}{8}$ in., laid in English bond.

For the purposes of this example the same basic rates as are used in Example No. 1 are taken.

This method of dealing with the "Extra Only" cost of facings over ordinary brickwork is similar to the method illustrated in Example No. 1, only it is based on 1,000 No. facing bricks and not 1 sq. yd. or 72 No. bricks. Referring to Example No. 1, it will be seen that the additional hours taken by the bricklayer and labourer in laying 72 No. facings is:

Bricklayer	0·60 hour per sq. yd. or per 72 No. facing bricks.
Labourer	0·96 hour per sq. yd. or per 72 No. facing bricks.

∴ The additional bricklayer and labourer hours per 1,000 facing bricks are:

Bricklayer hours $\frac{1{\cdot}000}{72} \times 0{\cdot}60 = 8{\cdot}33$ hours per 1,000 facing bricks.

Labourer hours $\frac{1{\cdot}000}{72} \times 0{\cdot}96 = 13{\cdot}33$ hours per 1,000 facing bricks.

The "Extra Only" cost of facings over ordinary bricks per 1,000 facing bricks, therefore, is:

Cost of 1,000 facing bricks at 125/- per 1,000 .. .. =	£6	5	0
Cost of 1,000 ordinary bricks at 83/4 per 1,000 .. =	£4	3	4
∴ Additional cost of 1,000 facing bricks .. .. =	£2	1	8
Additional bricklayer hours 8·33 at 2/4 per hour .. =		19	5
Additional labourer hours 13·33 at 2/- per hour .. =	£1	6	8
∴ "Extra Only" cost per 1,000 facing bricks .. .. =	£4	7	9

Single face work in English bond requires 72 No. facing bricks per sq. yd.

∴ The "Extra Only" cost of facings per sq. yd. is:

$\frac{72}{1,000}$ × £4 7 9

= 0·072 × 87/9

= 6/4 per sq. yd.

Note.—The above is exclusive of pointing and the result is the same as in Example No. 1.

Example No. 3.—Calculate the "Extra Cost" cost of facing with best picked stock bricks per sq. yd. in English bond, exclusive of pointing, using $8\frac{3}{4} \times 4\frac{3}{16} \times 2\frac{5}{8}$ in. stock bricks.

Note.—In this case the whole of the work is carried out with stock bricks, and the "extra only" is only the additional bricklayer and labourer hours involved in selecting and laying the bricks. Referring to Example No. 1, it will be seen that the extra bricklayer and labourer hours taken to hand-pick and lay facings in English bond single-faced work, exclusive of pointing, per sq. yd. is:

Bricklayer	0·60 hour per sq. yd.
Labourer	0·96 ,,
∴ The "Extra Only" cost per sq. yd. is:	
Bricklayer 0·60 hour at 2/4 per hour ..	16·80 pence per sq. yd.
Labourer 0·96 hour at 2/- per hour ..	23·04 ,,
	39·84 ,,
	3/4 per sq. yd.

Note.—The above is exclusive of pointing.

TABLE SHOWING THE AREA OF BRICKWORK OF VARIOUS THICKNESSES PER ROD

Type of brickwork	*Area of brickwork per rod*	
	Square feet	*Square yds.*
½ brick thick, 4½ in. work	816·00	90·66
1 brick thick, 9 in. work	408·00	45·33
1½ bricks thick, 14 in. work	272·00	30·25
2 bricks thick, 18 in. work	204·00	22·66
2½ bricks thick, 22½ in. work	163·00	18·16
3 bricks thick, 27 in. work	136·00	15·11

1 rod of brickwork = 272¼ sq. ft. of brickwork 14 in. thick.
1 rod of brickwork = 30¼ sq. yds. of brickwork 14 in. thick.
1 rod of brickwork = 306¼ cu. ft. of brickwork.
1 rod of brickwork = 11⅓ cu. yds. of brickwork.

Note.—In practice it is usual to ignore the odd fractions of square yards, square feet, cubic feet and cubic yards.

MORTAR FOR BRICKWORK

Note.—(1) The data shown are based on the following:

Cement weighing 90 lb. per cubic foot.
Lime weighing 45 lb. per cubic foot.

(2) The data shown relating to sand refer to "dry sand". If washed sand is employed, a multiplier of 1·25 should be used in conjunction with the quantities of sand shown in order to allow for bulkage due to the moisture content.

(3) If the mortar is mechanically mixed in a 4 ft. 6 in. diameter pan mortar mill, allow the following plant and labour hours for mixing per cu. yd. of mortar:

Nature of mortar	*Plant hours per cu. yd*	*Labour hours per cu. yd.*
Sand, lime	1·00	2·00
Sand, cement, lime	1·05	2·10
Sand, cement	1·10	2·20
Ash, lime	1·30	2·60

LIME MORTAR

Note.—Allow for mixing by hand 5·00 labour hours per cubic yard.

Mix		*Material required per cubic yard of mortar*	
Sand	*Lime*	*Sand cu. yds.*	*Lime tons*
1	1	0·73	0·40
1½	1	0·93	0·33
2	1	1·00	0·27
2½	1	1·07	0·23
3	1	1·10	0·20
3½	1	1·15	0·17
4	1	1·20	0·15

CEMENT LIME MORTAR

Note.—Allow for mixing by hand 6·00 labour hours per cubic yard.

Mix			*Material required per cubic yard of mortar*		
Sand	*Cement*	*Lime*	*Sand cu. yds.*	*Cement tons*	*Lime tons*
2	1	1	0·73	0·40	0·20
3	1	1	0·93	0·34	0·17
4	1	1	1·00	0·28	0·14
5	1	1	1·07	0·24	0·12
6	1	1	1·10	0·20	0·10
7	1	1	1·15	0·18	0·09
8	1	1	1·20	0·16	0·08

CEMENT MORTAR

Note.—Allow for mixing by hand 6·00 labour hours per cubic yard.

Mix		*Material required per cubic yard of mortar*	
Sand	*Cement*	*Sand cu. yds.*	*Cement tons*
1	1	0·73	0·79
1½	1	0·93	0·67
2	1	1·00	0·54
2½	1	1·07	0·46
3	1	1·10	0·39
3½	1	1·15	0·33
4	1	1·20	0·29

HOLLOW WALL TIES

Note.—(1) Ties are usually at 4 or 6 per sq. yd. and are sold by the cwt.

(2) The data shown are for wrought galvanized ties with twisted centre section and with forked swallow-tailed ends.

Dimensions of tie in inches	*Number of ties per cwt.*
8 × ¾ × ⅛	510
8 × ¾ × 3/16	340
8 × 1 × ⅛	390
8 × 1 × 3/16	260
8½ × ¾ × ⅛	480
8½ × ¾ × 3/16	320
8½ × 1 × ⅛	360
8½ × 1 × 3/16	240
9 × ¾ × ⅛	460
9 × ¾ × 3/16	310
9 × 1 × ⅛	330
9 × 1 × 3/16	220

HOOP IRON BOND

Gauge S.W.G.	*Width in inches*	*Lb. per* 100 *lin. ft.*	*Lin. ft. per cwt.*
13	2	63	177
14	1¾	47	238
15	1½	36	308
16	1¼	26	420
17	1⅛	21	585
18	1	16	692

STOCK BRICKWORK

Note.—(1) The data shown are for brickwork carried out with ⅜ in. joints in lime mortar to heights not in excess of 40 ft. For work to heights in excess of this see table of multipliers on p. 94.

(2) The number of bricks laid per bricklayer per hour on which the data are based is shown in each case. If this number is assessed at more or less than that shown, the bricklayer and labourer hours may be adjusted thus:

If the output tabulated is 60 bricks per hour and the assessed putput is 80 bricks per hour, use a labour multiplier with the bricklayer and labour hours shown of $\frac{60}{80} = 0{\cdot}75$.

(3) The data shown do not allow for knocking up the mortar. See mortar tables, pp. 90, 91.

(4) The data shown do not allow for pointing for which see p. 98.

(5) The data shown are for brickwork carried out in lime mortar. If the brickwork is carried out in cement mortar use a multiplier of 1·25 with the bricklayer and labourer hours shown.

(6) The labour hours shown do not allow for scaffolding, for which see p. 237.

(7) For hollow or cavity walls allow for fixing wall ties: bricklayer, 0·02 hour per tie; labourer 0·02 hour per tie.

BRICKS, 8¾ × 4 3/16 × 2 in.

Description Rough brickwork not pointed	Unit	Number of bricks laid per brick-layer per hr.	Number of bricks required	Mortar required cubic yards			Brick-layer hours	Labour hours
				No frogs	Single frogs	Double frogs		
Half-brick walls, 4½ in. work	sq. yd.	50	60	0·024	0·030	0·036	1·20	1·20
Two half-brick hollow walls, 11 in. work	sq. yd.	50	120	0·048	0·060	0·072	2·40	2·40
Solid brick walls, 9 in. work	sq. yd.	60	120	0·058	0·071	0·084	2·00	2·00
Brick and a half walls, 14 in. work	sq. yd.	70	180	0·082	0·101	0·120	2·58	2·58
Ditto, 14 in. work	rod	70	5430	2·680	3·252	3·826	77·60	77·60
Mass brickwork	cu. yd.	80	472	0·260	0·310	0·360	5·90	5·90
Mass brickwork	cu. ft.	80	18	0·010	0·012	0·014	0·23	0·23

BRICKS, 8¾ × 4 3/16 × 2⅝ in.

Description Rough brickwork not pointed	Unit	Number of bricks laid per brick-layer per hr.	Number of bricks required	Mortar required cubic yards			Brick-layer hours	Labour hours
				No frogs	Single frogs	Double frogs		
Half-brick walls, 4½ in. work	sq. yd.	50	48	0·020	0·024	0·028	0·96	0·96
Two half-brick hollow walls, 11 in. work	sq. yd.	50	96	0·040	0·050	0·060	1·92	1·92
Solid brick walls, 9 in. work	sq. yd.	60	96	0·050	0·060	0·070	1·60	1·60
Brick and a half walls, 14 in. work	sq. yd.	70	144	0·070	0·084	0·098	2·06	2·06
Ditto, 14 in. work	rod	70	4300	2·330	2·800	3·270	61·43	61·43
Mass brickwork	cu. yd.	80	375	0·230	0·270	0·310	4·70	4·70
Mass brickwork	cu. ft.	80	14	0·009	0·011	0·013	0·18	0·18

BRICKS, 8¾ × 4 3/16 × 2⅞ in.

Description Rough brickwork not pointed	Unit	Number of bricks laid per brick-layer per hr.	Number of bricks required	Mortar required cubic yards			Brick-layer hours	Labour hours
				No frogs	Single frogs	Double frogs		
Half-brick walls, 4½ in. work	sq. yd.	50	44	0·018	0·023	0·028	0·88	0·88
Two half-brick hollow walls, 11 in. work	sq. yd.	50	88	0·037	0·047	0·057	1·76	1·76
Solid brick walls, 9 in. work	sq. yd.	60	88	0·046	0·056	0·066	1·47	1·47
Brick and a half walls, 14 in. work	sq. yd.	70	132	0·064	0·079	0·094	1·89	1·89
Ditto, 14 in. work	rod	70	3970	2·234	2·660	3·086	56·72	56·72
Mass brickwork	cu. yd.	80	346	0·220	0·260	0·300	4·33	4·33
Mass brickwork	cu. ft.	80	13	0·008	0·010	0·012	0·16	0·16

STOCK BRICKWORK

Table of multipliers for use with the bricklayer and labourer hours shown in the stock brickwork table for carrying out work at height and various types of work.

Description	*Bricklayer and labour hour multipliers*
Brickwork built at height ranging from ground level to 40 ft.	1·00
Brickwork exceeding 40 ft. but not exceeding 60 ft.	1·20
Brickwork exceeding 60 ft. but not exceeding 80 ft.	1·30
Brickwork exceeding 80 ft. but not exceeding 100 ft.	1·40
Brickwork built in arches	2·50
Brickwork built to batter	1·50
Brickwork built in cement mortar	1·25
Brickwork built in chimneys	2·00
Brickwork built in flat sweeps	1·50
Brickwork built in heavy engineering bricks	1·25
Brickwork built in flues	1·80
Brickwork built to quick sweeps	2·00
Brickwork built overhand	1·10
Brickwork built in large chambers below ground level	1·10
Brickwork built in small chambers below ground level, manholes, etc.	1·20
Brickwork built in raising old walls	1·25
Brickwork built in sewers	3·20
Brickwork built in tapered walls	2·00
Brickwork built in underpinning	2·25

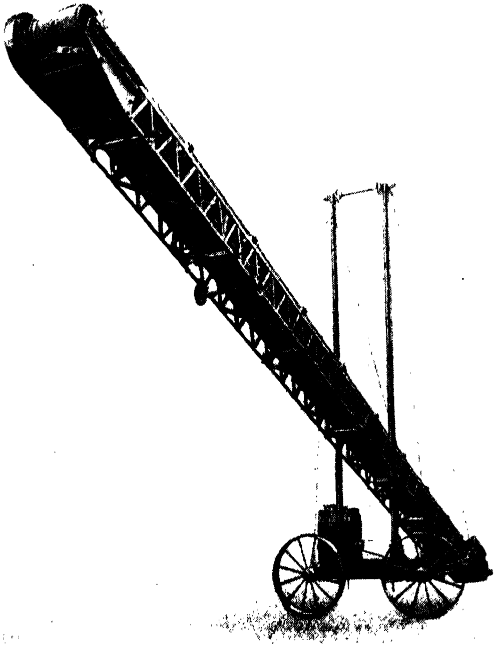


FIG. 6.—THE PARKER PORTABLE BELT LOADER WITH SWIVEL WHEELS

The wheels are arranged to swivel and are also adjustable for travelling in a straight line or working radially with the feed point as the pivot.

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STOCK BRICKWORK

Description	*Unit*	*Material*	*Bricklayer hours*	*Labour hours*
Beam filling, per 4½ in. width	Lin. ft.	—	0·12	0·12
Bedding wall plates, 4½ in. wide	Lin. ft.	—	0·10	0·10
Brick nogging on edge	Sq. yd.	30 bricks, 0·02 cu. yds. mortar	0·80	0·80
Brick nogging on flat	Sq. yd.	42 bricks, 0·03 cu. yds. mortar	1·00	1·00
Cutting and pinning landing edges, chase girth 6 in.	Lin. ft.	—	0·40	0·40
Cutting and pinning landing edges, chase girth 9 in.	Lin. ft.	—	0·60	0·60
Cutting and pinning landing edges, chase girth 12 in.	Lin. ft.	—	0·80	0·80
Cutting and pinning landing edges, chase girth 18 in.	Lin. ft.	—	1·00	1·00
Cutting, circular	Sq. ft.	1 brick for waste	0·50	0·50
Cutting, rough	Sq. ft.	1 brick for waste	0·25	0·25
Cutting toothing and bonding to old walls	Sq. ft.	—	0·60	0·60
Cutting and fitting brickwork to joists, etc., per 4½ in. width of cutting	Lin. ft.	—	0·25	0·25
Chases—horizontal, 3 in. girth	Lin. ft.	—	0·20	0·20
Chases—horizontal, 6 in. girth	Lin. ft.	—	0·30	0·30
Chases—horizontal, 9 in. girth	Lin. ft.	—	0·40	0·40
Chases—horizontal, 12 in. girth	Lin. ft.	—	0·50	0·50
Chases—horizontal, 18 in. girth	Lin. ft.	—	0·60	0·60
Chases—raking, 3 in. girth	Lin. ft.	—	0·40	0·40
Chases—raking, 6 in. girth	Lin. ft.	—	0·60	0·60
Chases—raking, 9 in. girth	Lin. ft.	—	0·80	0·80
Chases—raking, 12 in. girth	Lin. ft.	—	1·00	1·00
Chases—raking, 18 in. girth	Lin. ft.	—	1·20	1·20
Chases—vertical, 3 in. girth	Lin. ft.	—	0·30	0·30
Chases—vertical, 6 in. girth	Lin. ft.	—	0·45	0·45
Chases—vertical, 9 in. girth	Lin. ft.	—	0·60	0·60
Chases—vertical, 12 in. girth	Lin. ft.	—	0·75	0·75
Chases—vertical, 18 in. girth	Lin. ft.	—	0·90	0·90
Flues—form, parge and core:				
cross-sectional area 24 sq. in.	Lin. ft.	0·15 cu.ft. mortar	0·30	0·30
cross-sectional area 48 sq. in.	Lin. ft.	0·25 cu.ft. mortar	0·35	0·35
cross-sectional area 72 sq. in.	Lin. ft.	0·35 cu.ft. mortar	0·40	0·40
cross-sectional area 120 sq. in.	Lin. ft.	0·55 cu.ft. mortar	0·50	0·50
cross-sectional area 144 sq. in.	Lin. ft.	0·65 cu.ft. mortar	0·55	0·55
Hoop iron bond, single	Lin. yd.	1 lin. yd.	0·10	0·10
Oversailing course, per course	Lin. ft.	—	0·05	0·05
Projections to aprons	Sq. yd.	1 sq. yd. of 4½ in. brickwork and mortar as reqd.	1·40	1·40
Protections of friezes	Sq. yd.		1·00	1·00
Projections to pilasters	Sq. yd.		1·50	1·50
Protections to plinths	Sq. yd.		0·80	0·80
Reveals—cutting and waste	Lin. ft.	1 brick for waste	0·12	0·12
Rounded angles, 6 in. girth	Lin. ft.	—	0·40	0·40
Rounded angles, 9 in. girth	Lin. ft.	—	0·50	0·50
Rounded angles, 12 in. girth	Lin. ft.	—	0·60	0·60
Rounded angles, 18 in. girth	Lin. ft.	—	0·80	0·80
Splays, 9 in. wide	Lin. ft.	1 brick for waste	0·20	0·20
Splays, 14 in. wide	Lin. ft.	1½ bricks for waste	0·30	0·30
Splays, 18 in. wide	Lin. ft.	2 bricks for waste	0·40	0·40
Squints and birdsmouths with purpose made bricks	Lin. ft.	4 bricks for squints and 2 bricks for birdsmouths	0·12	0·12
Squints and birdsmouths with ordinary bricks	Lin. ft.	1 brick for waste	0·33	0·33
Wedging to underpinning	Sq. ft.	1 brick for waste	0·25	0·25

BRICK FACINGS

Note.—(1) The table shows the number of facing bricks required for facing work carried out in various bonds and also the additional or "*Extra Only*" bricklayer and labour hours taken to lay the facing bricks over ordinary brickwork per square yard.

(2) The data refer to good-class facing work with selected hand-picked facing bricks For seconds facings with no selection, the labourer hours may be taken as being the same as those shown in the table for bricklayer.

(3) The data shown refer to facing work carried out in sandfaced or multicoloured facings. For facings other than this, use the following multipliers with the bricklayer and labourer hours shown:

Facing work in Blue Staffordshire and similar bricks	1·50
Facing work in glazed bricks	2·00

(4) The data shown are exclusive of pointing, for which sec p. 98.

Type of work	*Size of bricks, number required and the* "Extra Only" *bricklayer and labourer hours over ordinary brickwork in laying facing bricks per square yard*								
	$8\frac{3}{4} \times 4\frac{3}{16} \times 2$ in.			$8\frac{3}{4} \times 4\frac{3}{16} \times 2\frac{5}{8}$ in.			$8\frac{3}{4} \times 4\frac{3}{16} \times 2\frac{7}{8}$ in.		
	No. facing bricks reqd.	*Bricklayer hours*	*Lab. hours*	*No. facing bricks reqd.*	*Bricklayer hours*	*Lab. hours*	*No. facing bricks reqd.*	*Bricklayer hours*	*Lab. hours*
English bond, single-faced work	90	0·75	1·20	72	0·60	0·96	66	0·55	0·88
Flemish bond, single-faced work	80	0·66	1·06	64	0·53	0·85	59	0·49	0·79
4½ in. or single-faced cavity work	60	0·50	0·80	48	0·40	0·64	44	0·36	0·58
9 in. solid and 11 in. cavity double-faced work ..	120	1·00	1·60	95	0·80	1·28	88	0·75	1·19
English garden wall bond, single-faced work ..	75	0·62	1·00	60	0·50	0·80	55	0·45	0·73
Flemish garden wall bond, single-faced work ..	69	0·58	0·93	55	0·46	0·74	51	0·43	0·68

BRICKWORK FACINGS

Table of multipliers for use with the bricklayer and labour hours shown in the brickwork facings table for carrying out various types of work

Description	*Bricklayer and labour hour multipliers*
Brickwork built in arches	5·50
Brickwork built in bands	1·50
Brickwork built to batter	1·25
Brickwork built to flat sweeps	1·50
Brickwork built in quick sweeps	2·00
Brickwork built to flush quoins	1·20
Brickwork built to projecting quoins	1·50
Brickwork built to small panels	2·60
Brickwork built to large panels	1·80
Brickwork built to overhand	1·25

BRICKWORK FACINGS

Description	*Unit*	*Material*	*Brick-layer hours*	*Labour hours*
Angles, chamfered—purpose made	Lin. ft.	4 bricks	0·25	0·25
Angles, chamfered—cut and rubbed	Lin. ft.	1 brick for waste	0·50	0·50
Angles, moulded—purpose made	Lin. ft.	4 bricks	0·25	0·25
Aprons	Sq. ft.	—	0·25	0·25
Aprons, return to	Lin. ft.	—	0·20	0·20
Aprons, shape edges of	Lin. ft.	—	0·25	0·25
Birdsmouths—purpose made	Lin. ft.	2 bricks	0·25	0·25
Birdsmouths—cut and rubbed	Lin. ft.	1½ bricks for waste	0·50	0·50
Copings—brick on edge per 9 in. width	Lin. ft.	4 bricks, 0·05 cu. ft. mortar	0·20	0·20
Copings—brick on flat, per 9 in. width	Lin. ft.	3 bricks, 0·05 cu. ft. mortar	0·15	0·15
Cutting, circular	Lin. ft	1 brick for waste	0·33	0·33
Cutting, horizontal	Lin. ft.	1 brick for waste	0·20	0·20
Cutting, raking	Lin. ft.	1 brick for waste	0·25	0·25
Cutting, vertical	Lin. ft.	1 brick for waste	0·12	0·12
Cutting against mouldings 6 in. girth	Each	1 brick for waste	0·50	0·50
Cutting against mouldings 12 in. girth	Each	2 bricks for waste	0·75	0·75
Cutting holes for pipes up to 3 in. diameter per 4½ in. thickness of wall	Each	—	1·00	1·00
Cutting holes for pipes over 3 in. but not exceeding 6 in. diameter per 4½ in. thickness of wall ..	Each	—	1·40	1·40
Cutting holes for pipes over 6 in. but not exceeding 9 in. diameter per 4½ in. thickness of wall ..	Each	—	2·00	2·00
Cuttings and rubbings to groin points	Lin. ft.	3 bricks for waste	0·90	0·90
Cuttings and rubbings to ribs per 4½ in. thickness	Lin. ft.	1 brick for waste	0·45	0·45
Dentil course up to 2¼ in. projection	Lin. ft.	—	0·10	0·10
Fair cutting and fitting facings to joists, etc., per 4½ in. width of cutting	Lin. ft.	2 bricks for waste	0·50	0·50
Moulded course per course to 2¼ in. projection ..	Lin. ft.	—	0·06	0·06
Moulded angles—purpose made	Lin. ft.	4 bricks	0·25	0·25
Notches in strings per 2¼ in. notch in one course ..	Each	—	0·60	0·60
Perforations in strings per 2¼ in. notch in one course	Each	—	1·50	1·50
Oversailing per course	Lin. ft.	—	0.06	0·06
Pilasters up to 14 in. width	Lin. ft.	—	0·50	0·50
Plinth course, per course to 2¼ in. projection ..	Lin. ft.	—	0·03	0·03
Plumbing to external angles	Lin. ft.	—	0·10	0·10
Reveals—cutting and waste	Lin. ft.	1 brick for waste	0·25	0·25
Squint quoins—purpose made	Lin. ft.	4 bricks	0·25	0·25
Squint quoins—cut and rubbed	Lin. ft.	2 bricks for waste	0·50	0·50
Tile creasings to 9 in. walls	Lin. ft.	5 tiles, 0·05 cu. ft. mortar	0·25	0·25
Tile creasings to 14 in. walls	Lin. ft.	7 tiles, 0·06 cu. ft. mortar	0·30	0·30
Toothing and bonding to old walls	Lin. ft.	1 brick for waste	0·33	0·33

RUBBED AND GAUGED BRICKWORK FACINGS

Description	*Unit*	*Material*	*Brick-layer hours*	*Labour hours*
Mouldings, cut and fix single course	Lin. ft.	2 bricks	1·50	1·50
External angle to single course	Lin. ft.	—	0·50	0·50
Internal angle to single course	Lin. ft.	—	0·75	0·75
Stops to single course	Each	—	0·60	0·60
Niche heads	Sq. ft.	12 bricks	7·00	7·00
External angle of arch to niche head	Lin. ft.	—	1·20	1·20
Facing to niches	Sq. ft.	10 bricks	2·50	2·50
External angle of niche facing	Lin. ft.	—	0·60	0·60
Sills to niches	Sq. ft.	—	0·60	0·60
Pilasters	Sq. ft.	—	0·50	0·50
Cutting and bonding pilasters to facing	Lin. ft.	—	0·60	0·60
Throatings	Lin. ft.	—	0·12	0·12
Weatherings	Sq. ft.	—	1·00	1·00
Cleaning down	Sq. ft.	—	0·25	0·25

POINTING BRICKWORK

Note.—(1) The bricklayer and labourer hours shown are for raking out the joints as the work proceeds and pointing as a separate operation with a neat weathered joint.

(2) The hours shown are for pointing with lime mortar. If cement mortar is used a labour multiplier of 1·25 should be used with the hours shown.

(3) The hours shown refer to $\frac{3}{8}$ in. joints

(4) For cement mortar tables see pp. 90, 91.

Type of bond	*Raking out the joints as the work proceeds and pointing as a separate operation with a weathered joint. Size of bricks, mortar required and bricklayer and labourer hours per square yard.*								
	$8\frac{3}{4} \times 4\frac{3}{16} \times 2$ in.			$8\frac{3}{4} \times 4\frac{3}{16} \times 2\frac{5}{8}$ in.			$8\frac{3}{4} \times 4\frac{3}{16} \times 2\frac{7}{8}$ in.		
	Mortar reqd. cu. ft.	*Brick-layer hours*	*Labour hours*	*Mortar reqd. cu. ft.*	*Brick-layer hours*	*Labour hours*	*Mortar reqd. cu. ft.*	*Brick-layer hours*	*Labour hours*
English bond	0·066	1·00	1·00	0·056	0·80	0·80	0·052	0·74	0·74
Flemish bond	0·062	0·95	0·95	0·054	0·77	0·77	0·050	0·70	0·70
Stretching bond	0·058	0·85	0·85	0·050	0·69	0·69	0·046	0·63	0·63
Heading bond	0·070	1·00	1·00	0·060	0·80	0·80	0·058	0·74	0·74
English garden bond	0·061	0·93	0·93	0·052	0·75	0·75	0·049	0·68	0·68
Flemish garden bond	0·060	0·90	0·90	0·050	0·72	0·72	0·048	0·66	0·66

MULTIPLIERS FOR USE WITH THE TABLE FOR POINTING BRICKWORK

Description	*Bricklayer and labourer hour multipliers*
Raking out the joints as the work proceeds and pointing with a neat weathered joint	1·00
Raking out joints only before the mortar is set	0·20
Raking out joints only in perished lime mortar	0·70
Raking out joints only in perished cement mortar	0·90
Pointing only with a neat weathered joint	0·80
Pointing as the work proceeds with a neat struck or flushed joint	0·25
Ironing joints as the work proceeds before mortar has set*	0·60
Tuck pointing	2·30

* This form of pointing consists of rubbing or ironing the joints with a $\frac{3}{8}$ in. diameter bent steel bar.

BRICKLAYER
SUNDRY WORKS

Description	*Unit*	*Material*	*Brick-layer hours*	*Labour hours*
Break down only brick walls built in lime mortar	Cu. yd.	—	—	1·60
Break down only brick walls built in cement mortar	Cu. yd.	—	—	2·40
Break down only stone walls built in lime mortar	Cu. yd.	—	—	2·00
Break down only stone walls built in cement mortar	Cu. yd.	—	—	3·00
Note.—Add loading and transporting if required. See Section No. 13.				
Bricks on edge steps or sills	Lin. ft.	4 bricks, 0·05 cu. ft. mortar	0·20	0·20
Brick on edge steps or sills radiating	Lin. ft.	4 bricks, 0·05 cu. ft. mortar	0·40	0·40
Fair ends to the above	Each	—	0·25	0·25
Cement fillets to roof joints	Lin. ft.	0·03 cu. ft. mortar	0·06	0·06
Cement wash	Sq. yd.	0·50 lb. cement	0·12	0·12
Clean and stack old bricks—lime mortar	per 1,000	—	—	18·00
Damp-proof course in bitumen—horizontal . .	Sq. ft.	Allow 5% for waste	0·02	0·02
Damp-proof course in bitumen—vertical	Sq. ft.	Allow 5% for waste	0·05	0·05
Damp-proof course in sheet lead—horizontal .	Sq. ft.	Allow 5% for waste	0·03	0·03
Damp-proof course in sheet lead—vertical	Sq. ft.	Allow 5% for waste	0·06	0·06
Damp-proof course in two courses of slates—horizontal	Sq. ft.	2 sq. ft. of slates	0·25	0·25
Damp-proof course in two courses of slates—vertical	Sq. ft.	0·05 cu. ft. mortar	0·50	0·50
Damp-proof course in two courses of bricks—horizontal	Sq. ft.	7 bricks, 0·10 cu. ft. mortar	0·30	0·30
Fix air bricks, 9 × 6 in.	Each	0·08 cu. ft. mortar	0·20	0·20
Fix caps to pillars	Sq. ft.	0·10 cu. ft. mortar	0·20	0·20
Fix channels, stoneware, 4 in. diameter	Lin. ft.	—	0·08	0·08
Fix channels, stoneware, 6 in. diameter	Lin. ft.	—	0·09	0·09
Fix channels, stoneware, 9 in. diameter	Lin. ft.	—	0·10	0·10
Fix channels, stoneware, 12 in. diameter	Lin. ft.	—	0·11	0·11
Fix chimney pots, 12 in. diameter	Each	0·10 cu. ft. mortar	0·60	0·60
Fix chimney bars	Each	—	0·10	0·10
Fix copings, 36 sq. in. in cross section	Lin. ft.	0·05 cu. ft. mortar	0·25	0·25
Fix copings, 48 sq. in. in cross section	Lin. ft.	0·06 cu. ft. mortar	0·26	0·26
Fix copings, 60 sq. in. in cross section	Lin. ft.	0·07 cu. ft. mortar	0·27	0·27
Fix copings, 72 sq. in. in cross section	Lin. ft.	0·08 cu. ft. mortar	0·29	0·29
Fix door- or window-frames	Sq. ft.	—	0·08	0·08
Fix interceptors, 4 in. diameter	Each	—	0·30	0·30
Fix interceptors, 6 in. diameter	Each	—	0·40	0·40
Fix interceptors, 9 in. diameter	Each	—	0·50	0·50
Fix manhole covers, 1 cwt.	Each	0·30 cu. ft. mortar	0·50	0·50
Fix manhole covers, 2 cwt.	Each	0·40 cu. ft. mortar	0·60	1·20
Fix manhole covers, 3 cwt.	Each	0·50 cu. ft. mortar	0·70	1·40
Fix manhole covers, 4 cwt.	Each	0·60 cu. ft. mortar	0·80	1·60
Fix manhole covers, 5 cwt.	Each	0·70 cu. ft. mortar	0·90	1·80
Fix manhole steps, iron	Each	—	0·10	0·10
Fix sinks on metal supports	Each	—	2·25	2·25
Fix tiles in cement to walls	Sq. ft.	Allow 5% waste 0·02 cu. ft. mortar	0·30	0·30
Hack brickwork for key	Sq. yd.	—	—	0·80
Hack concrete for key	Sq. yd.	—	—	1·00
Holes—cut and make good for pipes up to 3 in. diameter per 4½ in. thickness of wall	Each	—	1·00	1·00
Holes—cut and make good for pipes exceeding 3 in. but not exceeding 6 in diameter per 4½ in. thickness of wall	Each	—	1·40	1·40
Holes—cut and make good for pipes exceeding 6 in. but not exceeding 9 in. diameter per 4½ in. thickness of wall	Each	—	2·00	2·00
Lime whiting	Sq. yd.	0·60 lb. lime	0·10	0·10
Pointing to door- or window-frames	Lin. ft.	0·02 cu. ft. mortar	0·10	0·10
Pointing to verges	Lin. ft.	0·02 cu. ft. mortar	0·06	0·06

BRICKLAYER
SUNDRY WORKS (*continued*)

Description	*Unit*	*Material*	*Brick-layer hours*	*Labour hours*
Rake, wedge and point lead flashings	Lin. ft.	0·003 cu. ft. mortar	0·25	0·25
Rake, wedge and point step flashings	Lin. ft.	0·004 cu. ft. mortar	0·30	0·30
Reinforcement, see p. 139.				
Render chimney backs	Sq. yd.	0·50 cu. ft. mortar	0·30	0·30
Set and fix mantel register grates, 24 in.	Each	24 bricks 0·50 cu. ft. mortar	2·20	2·20
Set and fix mantel register grates, 36 in.	Each	32 bricks 0·80 cu. ft. mortar	2·60	2·60
Set and fix register grate, 36 in.	Each	32 bricks 0·80 cu. ft. mortar	2·00	2·00
Tiles—2 courses in cement for sills	Lin. ft.	4 tiles 0·10 cu. ft. mortar	0·50	0·50
Torching under slating	Square	0·60 cu. ft. mortar	1·60	1·60
Torching under tiling	Square	1·00 cu. ft. mortar	3·20	3·20
Unload and stack bricks	per 1,000	—	—	3·00
Wallplates—bedding 4½ in. wide	Lin. ft.	—	0·10	0·10

FIXING COPINGS, STRING COURSES AND SIMILAR WORK
HOLLOW PARTITION BLOCKS, ETC.

Description	*Unit*	*Mortar required cubic feet*	*Bricklayer hours*	*Labour hours*
Fix coping 9 in. wide	Lin. ft.	0·08	0·25	0·25
Fix coping 14 in. wide	Lin. ft.	0·12	0·30	0·30
Fix coping 18 in. wide	Lin. ft.	0·16	0·35	0·35
Fix coping 24 in. wide	Lin. ft.	0·20	0·40	0·40
Fix enriched work	Cu. ft.	0·12	0·70	0·70
Fix moulded work	Cu. ft.	0·12	0·60	0·60
Fix plain work	Cu. ft.	0·12	0·40	0·40
Fix splayed work	Cu. ft.	0·12	0·50	0·50
Fix 3 in. string courses	Lin. ft.	0·03	0·12	0·12
Fix 6 in. string courses	Lin. ft.	0·06	0·16	0·16
Fix 9 in. string courses	Lin. ft.	0·09	0·20	0·20
Fix caps to 14 in. pillars	Each	0·10	0·40	0·40
Fix caps to 18 in. pillars	Each	0·15	0·60	0·60
Fix caps to 24 in. pillars	Each	0·20	0·80	0·80
Fix hollow partition blocks, 3 in. thick	Sq. yd.	0·25	0·70	0·70
Fix hollow partition blocks, 4 in. thick	Sq. yd.	0·30	0·80	0·80
Fix hollow partition blocks, 5 in. thick	Sq. yd.	0·35	0·90	0·90
Fix hollow partition blocks, 6 in. thick	Sq. yd.	0·40	1·00	1·00

BREEZE SLABS
WORK IN WALLS

Thickness of slab in inches	*Unit*	*Mortar required cubic feet*	*Bricklayer hours*	*Labour hours*
2 in.	Sq. yd.	0·18	0·50	0·50
2½ in.	Sq. yd.	0·21	0·55	0·55
3 in.	Sq. yd.	0·25	0·60	0·60
4 in.	Sq. yd.	0·30	0·70	0·70

SECTION ELEVEN

★

CARPENTER AND IRONMONGER

In connection with the above, constants are shown for carpenter and labour hours to carry out various items of work. The labour hours include for all off-loading, stacking and any re-handling of timber necessary. Labour multipliers are shown to cover such items as walls built to slope as compared with vertical, etc. and in this way the tables are kept compact, simple, and make for speedy reference.

It will be noted that, under the labour columns in the estimating tables, a certain amount of hours may be tabulated where one would be inclined to think no labour should appear; e.g. a carpenter usually fixes a door himself, if it be a light door, but labour was involved in off-loading, stacking and handling this door to the carpenter. The constants make allowance for all such cost.

At the end of the Section are shown tables in connection with timber, lineal feet per cubic feet, etc., whilst in Section Eight is shown in tabular form the number of labourers required per carpenter to carry out different types of work. This table shows the apportionment of labourers to carpenters for average works but there may be deviation from this dependent on the class and size of work involved, thus on a large floor which has to be boarded two carpenters per labourer might have to be employed, whilst on other and smaller work one might be sufficient.

In estimating, however, one has to use one's judgment and initiative, and, knowing the type of work which has to be done, tender accordingly. The labour hours shown are for average work and conditions and should, in general, be used as they stand.

Allowing for Wastage on Timber

It is a trade custom to sell prepared timber without making any allowance for cutting, sawing and planing, and there is therefore a loss in covering area in the case of boarding, and feet in the case of material bought per lineal foot or per foot cube.

A supplier of timber does not stock timber cut to lengths or inches, thus, if twenty joists were required for the work, say 4″ × 2″ × 9′ 8″ long and ordered as such, the merchant would probably only have 10-foot lengths in stock; there would therefore be a loss of 4 inches in each length.

These wastages of timber must be allowed for when estimating, and this is done by adding a percentage addition to the cost of the timber per foot cube, per foot lineal or per square, as the case may be. These percentages vary for different classes of timber and overleaf are shown fair average percentages which should be used.

Shuttering to Walls and large Beams per square yard

The shuttering timber is assumed to be wrot one face, 1¼″ thick out of 1½″ boarding. The labourer hours allow for all off-loading, stacking, handling and attendance on the carpenter. These hours represent the time taken for one face of

TABLE SHOWING ALLOWANCE TO ADD TO TIMBER COST TO COVER WASTE DUE TO CUT ENDS, ETC.

Description	*Percentage addition to add to cost of timber*
Cubed timber	7%
Wrot timber boarding, etc.	6%
Skirtings, mouldings, etc.	5%

wall only, i.e. one square yard. If both the wall faces have to be shuttered they must then both be measured. In the table shown one prop is allowed for every one square yard or less of shuttered face. It is possible, however, that more props may be required depending on the nature and size of the work. The labour per square yard putting in the props would therefore be variable. To allow for this, labour multipliers are shown for various numbers of props to the square yard. Props are assumed to be 4″ × 4″ for all lengths up to 12 feet and 6″ × 6″ from 12 to 20 feet. The estimator, knowing what work has to be constructed, must assess what number of props per square yard will be required and tender accordingly.

Material Cost of Timber per square yard

The cost of the timber chargeable per square yard, when preparing the estimate, depends to a great extent on how many times it can be used. Thus, if the shuttering can be used only once the whole of its cost, including all battens, props, etc., per square yard must be charged with a certain credit allowance for the value of the timber recovered. This recovery value depends on the type of shuttering. If the work requires severe cutting, fitting to angles, etc., the recovery value will be small, but in the case of flat work its recovery value may be as much as 50 to 80 per cent of its original cost. In cases where the shuttering is repetition work such as walls where it can be used more than once, the number of uses for estimating purposes is usually taken as about five. In such cases the initial cost is worked out per square yard and divided by five and after five uses the timber is usually written off as of no further use. The estimator must therefore assess the number of times he can use the shuttering or its recoverable value knowing the class of work which has to be carried out.

EXAMPLE

A wall has to be constructed requiring the following timber per square yard for the shuttering:

1¼ in. wrot boarding	1 sq. yd. at say	7/- =	7/-
4×4 in. propping timber . .	0·80 cu. ft. at	6/- =	4/10
9×3 in. waling and battens . .	0·80 cu. ft. at	6/- =	4/10
			16/8
Add for wastage	6%	=	0/10
∴ Cost per sq. yd. for timber		=	17/6

Assuming used once only

Material cost	per sq. yd.	17/6
∴ Less recoverable value, say 80%		14/0
Allow for timber cost/sq. yd. in estimate		3/6
∴ Allow for nails, say 1 lb. at 6*d.*		0/6
∴ Total cost of Shuttering material on which to base estimate		4/0

Note.—The estimator must assess the recoverable value knowing the type of work to be constructed.

Assuming five uses of shuttering

Material cost	per sq. yd.	17/6
Allow for nails, first use	=	0/6
Allow for nails for each re-use 0·25 lbs. per sq. yd. (other four uses)	=	0/6
∴ Cost per sq. yd.	=	18/6

Allowing five uses, cost per sq. yd. on which to base estimate $\frac{18/6}{5}$

3/9 sq. yd.

Note.—Allow 1 lb. nails per sq. yd. for first use and 0·25 lbs. for each re-use.

Labour Erection Costs of Shuttering when used more than once

If the shuttering is used more than once the subsequent erecting is less costly than the first always provided that the work is straightforward without necessitating a lot of cutting or alteration to the shuttering.

Multipliers:

Multipliers are shown for use with carpenter and labourer hours to cover such work as:

Repetition shuttering
Walls built to batter and slopes, etc.
„ „ circular to slow easy sweeps
„ „ „ „ quick sweeps
Various numbers of props per square yard

SHUTTERING TO WALLS AND LARGE BEAMS PER SQUARE YARD

Description (one prop per square yard)	*Unit*	*Carpenter hours*	*Labourer hours*
Erect and strike vertical shuttering 0′–10′ high	per sq. yd.	0·60	1·20
„ „ „ „ „ 10′–15′ „	„	0·70	1·40
„ „ „ „ „ 15′–20′ „	„	0·80	1·60

MULTIPLIERS FOR USE WITH THE TABLE "SHUTTERING TO WALLS AND LARGE BEAMS PER SQUARE YARD"

Description	*Multipliers*
Shuttering used once	1·00
„ „ twice per use	0·85
„ „ three times per use	0·80
„ „ four times „ „	0·78
„ „ five times „ „	0·76
Struts, 1 per sq. yd.	1·00
„ 1⅓ „ „	1·10
„ 1⅔ „ „	1·20
„ 2 „ „	1·30
Walls built batter or slopes	1·30
„ „ circular to large sweeps	1·50
„ „ „ „ quick „	2·00

Nails

Allow 1 lb. per sq. yd. for first use.

Allow ¼ lb. per sq. yd. for each re-use.

Wastage on timber. Allow 6%.

Shuttering to Roofs and Floors per square yard

The shuttering is assumed to be wrot one face, 1¼″ thick out of 1½″ boarding. The labour hours allow for all off-loading, stacking, handling, and attending on carpenter. In the table shown, one strut is allowed for every 1½ square yards or less of shuttered face. It is possible, however, that more struts may be necessary, depending on the nature and size of the work. The labour necessary to put in the struts is therefore variable. To allow for this, labour multipliers are shown for various numbers of struts per square yard. Struts are assumed to be 4″×4″ up to 12 feet long and 6″×6″ from 12 to 20 feet long. The estimator, knowing what work has to be constructed, must assess what number of struts per square yard will be required and tender accordingly.

Alternative Formwork

Formwork to Roofs and Walls may be carried out with Steel or Metal Formwork, so designed that it may be readily erected and struck. A certain amount of timber is required in connection with its erection, propping and strutting.

In building up a price for the Use or Hire of the Formwork, allow for it at so much per square yard of Formwork fixed, based on the Hire Rate charged for the Forms and the total area of surface on which they will be used.

For Estimating the Labour Cost of Erecting and Striking such Formwork the following Data may be used. The hours shown include for *Shoring* and *Propping* and the Erecting and Striking of the Formwork complete.

Metal Formwork to Walls and Roofs	*Fixed Hours*	*Labourer Hours*
Erect and strike formwork to vertical walls:		
0–10 ft. high per sq. yd.	0·48	0·96
10–15 ft. high per sq. yd.	0·56	1·12
15–20 ft. high per sq. yd.	0·64	1·28
For formwork to battered walls use a multiplier of 1·30 with the hours shown.		
Erect and strike formwork to roofs:		
0–10 ft. high per sq. yd.	0·48	0·48
10–15 ft. high per sq. yd.	0·57	0·57
15–20 ft. high per sq. yd.	0·68	0·68

Reverting to timber formwork, the next page shows how the cost of formwork varies depending on the number of times it is used.

EXAMPLE

A roof has to be shuttered requiring the following timber per sq. yd. for the shuttering.

1¼ in. wrot boarding .. .. 1 sq. yd. at say 7/- = 7/-
4×4 in. props .. .. .. 0·80 cu. ft. at 6/- = 4/10
Battens, etc. .. .. 0·72 cu. ft. at 6/- = 4/4

16/2
Add for wastage 6% 1/-

∴ Cost per sq. yd. for timber .. .. = 17/2

Assuming used once only

Material cost .. .. per sq. yd. = 16/2
Less recoverable value 60% say = 10/8

∴ Allow for timber cost per sq. yd. in estimate .. = 6/6
∴ Allow for nails, say 1 lb. at 6*d.* .. .. .. = 0/6

∴ Total cost of shuttering material per sq. yd on which to base estimate .. .. = 7/-

Note.—The estimator must assess the recoverable value knowing the type of work to be constructed.

Assuming five uses

Material cost .. .. per sq. yd. = 17/2
Allow for nails, first use: 1 lb. at 6*d.* .. .. .. = 0/6

17/8

Allow for nails for each re-use 0·25 lb. per sq. yd. Four other uses .. .. = 0/6

∴ Cost per sq. yd. .. .. = 18/2

Allowing for five uses. Cost per sq. yd. on which to base estimate .. .. = $\frac{18/2}{5}$
= 3/8 sq. yd. say.

Note.—Allow 1 lb. nails per sq. yd. for first use and 0·25 lb. for each re-use.

Labour Erection Costs of Shuttering when used more than once

If the shuttering is used more than once the subsequent erecting is less costly than the first, always provided that the work is straightforward without necessitating a great deal of cutting or alteration to the shuttering.

Multipliers:

Multipliers are shown for use with carpenter and labourer hours to cover such work as:

(1) Repetition shuttering; (2) Shuttering built to slopes; (3) Shuttering built circular to slow sweeps; (4) Shuttering built circular to quick sweeps; (3) Various numbers of struts per square yard.

SHUTTERING TO ROOFS AND FLOORS PER SQUARE YARD

Description *(one strut per 1½ sq. yds.)*	*Unit*	*Carpenter hours*	*Labourer hours*
Erect and strike horizontal shuttering 0′–10′ high	sq. yds.	0·60	0·60
„ „ „ „ „ 10′–15′ „	„	0·70	0·70
„ „ „ „ „ 15′–20′ „	„	0·80	0·80

MULTIPLIERS FOR USE WITH THE ABOVE TABLE

Description	*Multipliers*
Shuttering used once	1·00
„ „ twice per use	0·80
„ „ three times per use	0·73
„ „ four times „ „	0·70
„ „ five times „ „	0·68
„ built to slope 22½° from horizontal	1·25
„ „ „ „ 45° „ „	1·30
„ „ „ „ 67½° „ „	1·50
„ „ circular to large radius	1·60
„ „ „ „ small „	2·10
Struts, ⅔ per sq. yd.	1·00
„ 1⅓ „ „	1·10
„ 2 „ „	1·20
„ 2⅔ „ „	1·30
„ 3⅓ „ „	1·40
„ 4 „ „	1·50

Nails.

Allow 1 lb. per sq. yd. for first use.

Wastage on Timber. Allow 6%.

Shuttering to Piers, Braces, Columns, Joists, etc., per square yard

This can be really costly work due to the cutting and fitting to angles, etc., involved, particularly in small area work such as around rolled steel joists. In such cases the timber is of little use afterwards. In pricing this class of work, therefore, the recovery value of the timber must be carefully assessed. The shuttering timber is assumed to be wrot one face of 1¼″ thickness out of 1½″ boarding. The labour hour constants allow for all off-loading, stacking, handling and attending on the carpenter.

Material Cost of Timber per square yard

In this type of work there is often considerable waste and this may be as much as 100%. In estimating the timber cost per square yard, therefore, the estimator must carefully assess this waste. In the case of large beams of fair area the wastage may be fairly low, but in casings to rolled steel joists it may be really high. Really careful assessment is therefore necessary. If used more than once the value of the timber for estimating purposes is usually considered nil after five uses.

Example.—Assuming one use. A column has to be shuttered and it is assessed that the timber will only be worth 50% of its original value when struck due to cutting, etc. The following timber being required per square yard:

EXAMPLE

Assuming one use

A column has to be shuttered and it is assessed that the timber will only be worth 50% of its original value when struck due to cutting, etc. The following timber being required per sq. yd.:

1¼ in. wrot boarding	1 sq. yd. at say 7/- =	7/-
6×1½ in. battens	Say 1·20 cu. ft. at 6/- =	7/2
		14/2
Allow for wastage, say 7%	=	1/-
		15/2
∴ Assessed recoverable value of timber, say 50% ..	=	7/7
∴ Allow for timber cost in estimate	=	7/7
∴ Add for nails: 1 lb. at 5*d.*	=	0/5
∴ Total cost of shuttering material per sq. yd. on which to base estimate	=	8/-

Assuming shuttering can be used twice

The material cost per sq. yd. being the same as above.

Material cost per sq. yd.	15/2
Assessed recovery value after two uses, say 33⅓ ..	5/1
	10/1
Allow nails. First use 1 lb. at 5*d.*	0/5
Allow nails. Second use ¼ lb. at 5*d.*	0/2
	10/8

Allowing two uses. Cost per sq. yd. on which to base estimate $= \frac{10/8}{2} =$ 5/4 per sq.yd.

Note.—Allow 1 lb. of nails per sq. yd. for first use and 0·25 lb. for each re-use.

Multipliers:

Multipliers are shown for use with carpenter and labour hours to cover such work as:

Repetition work.
Shuttering erected to slope.
,, ,, ,, circular shape.
,, ,, ,, straight-sided figures, such as six-sided, etc.

SHUTTERING TO PIERS, BRACES, COLUMNS AND JOISTS PER SQUARE YARD

(for Multipliers, see page 109)

Description	*Unit*	*Carpenter hours*	*Labourer hours*
Erect and strike shuttering to beams, braces, columns, etc. 0′–10′ high ..	sq. yds.	1·00	1·00
,, ,, ,, ,, ,, ,, ,, ,, 10′–15′ ,, ..	,,	1·20	1·20
,, ,, ,, ,, ,, ,, ,, ,, 15′–20′ ,, ..	,,	1·50	1·50

Formwork or Moulds for Precast Concrete Units per cubic foot of Concrete Unit

The cost of a precast concrete unit depends greatly on:

1. The original cost of the mould.
2. The number of units which can be produced from the mould, before it is worn out and unfit for further use.

For this class of work the moulds have to be substantially made and finished in order that the mould may stand up to repeated use and that the unit, when struck, shall be sound and of good finish. The mould is a fairly costly article to produce, when costed at so much each, but it will be appreciated that if it can be used, say, fifty times before it is unfit for further use the initial cost is not so alarming. The timber used must be of first quality, well seasoned, and wastage must be allowed for as there is usually considerable cutting, planing, etc. Some moulds are really intricate with many angles, whilst others may be straightforward moulds such as for slabs, etc., and the percentage waste in these is less than in the former. The estimator must therefore assess the likely wastage on the timber depending on the class of mould to be made and allow a percentage addition to the timber cost to allow for this. An allowance of from 10% to 20% covers most unit work depending on the intricacy of the mould.

Concrete unit work is costed for and estimated for in cube feet and in allowing for the mould cost per foot cube. The procedure is as follows:

1. Calculate the cost of the mould.
2. Assess the number of times it can be used.
3. Calculate the volume of the unit in foot cube.
4. Calculate the cost of form per foot cube of unit, having assessed the number of times the mould can be used.

EXAMPLE

(Unit whose volume is say ¾ cu. ft.)

Assume material required for one mould is as follows:

5×2 timber		0·60 ft. at 6/9	=	4/-
1½ wrot one face boarding	say	4 sq. ft. at 10*d.*	=	3/4
2×1 in.	say	0·20 cu. ft. at 6/9	=	1/4
Nails and screws	say	1/-	=	1/-
Four bolts	say	each 1/1	=	4/4
				14/-
Allow for wastage, say 11%			=	1/6
∴ Material cost of mould			=	15/6
Carpenter hours making mould, say 5 hours at 2/6			=	12/6
∴ Total cost of one mould			=	28/- each

Assuming it has been assessed that the mould can be used 40 times

Volume of concrete units = 40 × ¾ cu. ft.
= 30 cu. ft.

∴ Mould cost per cu. ft. of precast concrete unit .. = $\frac{28/-}{30}$

∴ Amount to allow for mould in estimate .. .. = 0/11¼ per cu. ft.

MULTIPLIERS FOR USE WITH THE TABLE "SHUTTERING TO PIERS, BRACES, COLUMNS AND JOISTS PER SQUARE YARD"

Description	*Multipliers*
Shuttering used once	1·00
,, ,, twice per use	0·97
,, ,, three times per use	0·87
,, ,, four ,, ,, ,,	0·65
,, ,, five ,, ,, ,,	0·84
,, to slopes	1·40
,, ,, circular shape	3·00
,, ,, shaped sided, e.g. six-sided	1·60

Nails. Allow 1 lb. per sq. yd. for first use.
,, ,, ,, ,, ,, ,, each re-use.

For concreting to mould precast unit work, see page 131. In order to illustrate the method of calculating this cost of mould per cubic foot of concrete units, three units will be shown, viz. kerb, paving slabs and fence posts. For other types of units the estimator can build up his estimate on similar lines.

FORMWORK OR MOULDS FOR PRECAST CONCRETE UNIT CONSTRUCTION, PER CUBIC FOOT OF CONCRETE UNIT

Description				*Unit*	*Carpenter hours making one mould*
10×5 *in. Flat Kerb in* 3 *ft. lengths*					
Volume of 1 kerb = 1 cubic foot				per mould	8·50
Cost of Material per mould					
5×2 in. timber wrot one face	0·56 cu. ft. at say	6/9	= 3/9		
1 in. fillet	3 ft. at say	0/1	= 0/3		
1½ in. board wrot, one face	4 sq. ft. at say	0/10	= 3/4		
Nails	½ lb. at say	0/6	= 0/3		
Screws	,, at say	0/3	= 0/3		
2 bolts	,, at say	4/5	= 4/5		
			12/3		
Add say 10% wastage of timber			0/9		
			13/-		
∴ Material cost in mould =					
Carpenter hours per mould 5·00 at say 2/-			= 10/-		
∴ Cost of one mould complete			= 23/-		
Assuming it is assessed mould can be used 60 No. times					
No. of cubic feet of kerb produced per mould =					
60×1 cubic feet			= 60 cubic feet		
Mould cost per cubic foot on which to base estimate = $\frac{23/-}{60}$					
= 4·60 *pence per cubic foot*					

(*Table continued on page 110*)

FORMWORK OR MOULDS FOR PRECAST CONCRETE UNIT CONSTRUCTION PER CUBIC FOOT OF CONCRETE UNIT (*Contd.*)

Description	*Unit*	*Carpenter Hours making One Mould*
2 *in. Paving Slabs* 3 × 2 *ft.* Volume of 1 slab = 1 cubic foot *Cost of Material per mould* 2½ × 2 in. timber wrot one face 0·40 cu. ft. at say 6/9 = 3/3 1 board wrot one face .. 8·20 sq. ft. at say 0/7 = 4/9 Nails .. .. ½ lb. at say 0/6 = 0/3 Screws .. .. .. at say 0/3 = 0/3 8/6 Add 10% wastage of timber = 0/9 9/3 ∴ Carpenter hours per mould 5·25 at 2/- = 10/6 ∴ Cost of 1 mould complete = 19/9 Assuming it is assessed, mould can be used 50 times. No. of cubic feet of paving produced per mould = 50 × 1 cubic feet = 50 cubic feet Mould cost per cubic foot on which to base estimate $\frac{19/9}{50}$ = 4¾ pence per cubic foot	per mould	6·00
Fence Posts 4 × 4 *in.* × 6 *ft.* Volume of 1 post = 2/3 cubic feet *Cost of Material per mould* 6 × 1½ timber wrot one face 0·60 cubic feet 6/9 = 4/- 4 × 1½ timber wrot one face 0·70 cubic feet 6/9 = 4/9 Nails .. .. 1 lb. say at 0/6 = 0/6 2 bolts .. .. .. say = 0/9 10/- Add 10% wastage on timber = 0/10 ∴ Material cost of mould = 10/10 Carpenter hours per mould 6·00 say at 2/- = 12/- Cost of 1 mould complete = 22/10 Assuming it is assessed mould can be used 48 times. No. of cubic feet of posts produced per mould = 48 × 2/3 cubic feet = 32 cubic feet ∴ Mould cost per cubic foot on which to base estimate = $\frac{22/10}{32}$ = 8·56 pence per cu. foot	per mould	7·00

MULTIPLIERS FOR USE WITH THE TABLE "WORK TO FLOORS" (PAGE 111) FOR FLOORBOARD LAYING

Floorboard thickness	*Multipliers*
Up to 1″	1·00
" 1¼″	1·20
" 1½″	1·40
" 1¾″	1·60
" 2″	1·80

Allow for wastage on timber 7%

For table showing lin. ft. per cu. ft. and cu. ft. per lin. ft. see page 113.

WORK TO FLOORS

Multipliers.—Multipliers are shown for floorboarding in excess of 1″ thickness.

For sundry works see tables on page 112.

Description	*Unit*	*Carpenter hours*	*Labourer hours*
Fix joists, 2″ × 4″	cu. ft.	0·50	0·50
,, ,, 2″ × 6″	,,	0·45	0·45
,, ,, 2″ × 9″	,,	0·40	0·40
,, ,, 3″ × 4″	,,	0·45	0·45
,, ,, 3″ × 6″	,,	0·40	0·40
,, ,, 3″ × 9″	,,	0·35	0·35
,, ,, 4″ × 4″	,,	0·40	0·40
,, ,, 4″ × 6″	,,	0·35	0·35
,, ,, 4″ × 9″	,,	0·30	0·30
Trim ends of joists, 4″	each	0·20	0·20
,, ,, ,, ,, 6″	,,	0·25	0·25
,, ,, ,, ,, 9″	,,	0·30	0·30
Strutting to joists, solid	lin. ft.	0·10	0·10
,, ,, ,, herringbone	,,	0·15	0·15
Lay floorboards up to 1″ thickness, 6″ boards . ..	sq. ft.	0·04	0·04
,, ,, ,, ,, ,, 9″ ,, ...	,,	0·03	0·03
Fix ceiling boards, 6″ wide	,,	0·10	0·10
,, wall plates	cu. ft.	0·15	0·12

WORK TO ROOFS

Multipliers.—Multipliers are shown for roof boarding in excess of 1″ thickness (see also table on page 112).

Description	*Unit*	*Carpenter hours*	*Labourer hours*
Fix rafters (not framed)	cu. ft.	0·50	0·25
,, hip and valley rafters	,,	0·80	0·40
,, ceiling joists	,,	0·40	0·20
,, ,, boards	sq. ft.	0·10	0·10
,, collars	cu. ft.	0·60	0·30
,, purlins	,,	0·50	0·25
,, ridge boards	,,	0·70	0·35
,, wall plates	,,	0·30	0·30
,, cleats for purlins	each	0·80	0·40
Shape ends of rafters	,,	0·30	0·15
Fix gutterboards	sq. ft.	0·20	0·20
Mitres to gutters	each	0·06	0·06
Intersections to gutters	,,	0·20	0·20
Gussets to gutters	,,	0·10	0·10
Fix roofboarding 4″ wide up to 1″ thick	sq. ft.	0·05	0·05
,, ,, ,, 6″ ,, ,, ,, ,, ...	,,	0·04	0·04
,, ,, ,, 9″ ,, ,, ,, ,, ...	,,	0·03	0·03
,, fascias	lin. ft.	0·04	0·04
,, ,, to dormers	,,	0·08	0·08
,, barge boards	sq. ft.	0·15	0·15
,, ,, ,, to dormers	,,	0·25	0·25

MULTIPLIERS FOR USE WITH THE ABOVE TABLE FOR ROOFBOARD LAYING

For table showing lin. ft. per cu. ft. and cu. ft. per lin. ft. see page 113.

Roofboard thickness *Allow for wastage of timber 7%*	*Multipliers*
Up to 1″	1·00
,, 1¼″	1·20
,, 1½″	1·40

FIXING OF GROUNDS, MOULDINGS, CORNICES, SKIRTINGS, ETC.

Description		*Unit*	*Carpenter hours*	*Labourer hours*
Fix architraves, 6″	Nailed	lin. ft.	0·03	0·03
„ „ 9″	„	„	0·04	0·04
„ „ 6″	Plugged to walls	„	0·14	0·14
„ „ 9″	„ „ „	„	0·20	0·20
„ battening	Nailed	„	0·12	0·12
„ „	Plugged to walls	„	0·07	0·07
„ cornices	Nailed	sq. ft.	0·20	0·20
„ cornice brackets including plugging	Plugged	„	0·40	0·40
„ door frames, 3″ × 2″	Plugged to walls	lin. ft.	0·06	0·06
„ „ „ 3″ × 3″	„ „ „	„	0·07	0·07
„ „ „ 4″ × 2″	„ „ „	„	0·08	0·08
„ „ „ 4″ × 3″	„ „ „	„	0·09	0·09
„ door linings		„	0·06	0·06
„ doors 1½″ thick (no ironmongery)		sq. ft.	0·03	0·03
„ „ 2″ „ (for ironmongery, see page 92)		„	0·04	0·04
„ „ 2½″		„	0·05	0·05
„ door beading		lin. ft.	0·04	0·04
„ grounds, single	Nailed	„	0·02	0·02
„ „ double	„	„	0·03	0·03
„ „ single	Plugged to walls	„	0·07	0·07
„ „ double	„ „ „	„	0·12	0·12
„ mouldings up to 3″ wide	Nailed	„	0·02	0·02
„ „ „ „	Plugged to walls	„	0·06	0·06
„ skirting, 6″	Nailed	„	0·03	0·03
„ „ 9″	„	„	0·04	0·04
„ „ 6″	Plugged to walls	„	0·14	0·14
„ „ 9″	„ „ „	„	0·17	0·17
„ window frames (usually done by bricklayer)		sq. ft.	0·10	0·10
„ windows up to 5′ square area		each	0·50	0·50
„ „ „ 5′–10′ „		„	0·90	0·90
„ „ „ 10′–20′ „		„	1·60	1·60

SUNDRY WORKS IN CONNECTION WITH CARPENTRY

Description	*Unit*	*Carpenter hours*	*Labourer hours*
Cutting—straight per 1″ thickness	lin. ft.	0·10	—
„ raking „ „	„	0·15	—
„ circular „ „	„	0·20	—
Chamfers to 1″ girth	„	0·03	—
Holes ½″ dia.—boring	each	0·02	—
„ ¾″ „ „	„	0·04	—
„ 1″ „ „	„	0·06	—
„ box off in concrete floors for bolts, etc.	sq. ft.	0·50	—
Planing timber by hand	„	0·08	—
Plugging to walls, ½″ plugs	each	0·40	—
„ „ „ ¾″ „	„	0·60	—
„ „ „ 1″ „	„	0·80	—
Rounded edges	lin. ft.	0·06	—
Rebates or grooves to 1″ girth	„	0·10	—
Shelving, fixed	sq. ft.	0·10	0·10
Shelf bearers or brackets	lin. ft.	0·20	0·20
W.C. back boards	each	1·20	—
Windows fixed up to 5′ square area	„	0·50	0·50
„ „ „ 5′–10′ „	„	0·90	0·90
„ „ „ 10′–20′ „	„	1·60	1·60

TABLE SHOWING LINEAL FEET PER CUBIC FOOT AND CUBIC FEET PER LINEAL FOOT FOR TIMBER OF VARIOUS CROSS SECTIONS

Cross sectional area of timber in sq. inches	*Lin. ft. per cu. ft.*	*Cu. ft. per lin. ft.*	*Cross sectional area of timber in sq. inches*	*Lin. ft. per cu. ft.*	*Cu. ft. per lin. ft.*
1	144	0·007	10	14·40	0·069
1½	96	0·010	11	13·10	0·076
2	72	0·014	12	12	0·083
2½	57·60	0·017	15	9·60	0·104
3	48	0·021	24	6	0·166
3½	41·10	0·024	30	4·80	0·208
4	36	0·028	36	4	0·250
4½	32	0·031	42	3·40	0·294
5	28·80	0·035	48	3	0·332
5½	26·20	0·038	54	2·70	0·370
6	24	0·041	60	2·40	0·416
7	20·60	0·049	66	2·20	0·453
8	18	0·055	72	2	0·500
9	16	0·062			

Note.—The above table can usefully be employed in conjunction with the estimating tables for converting the labour hours as shown per cu. ft. to the labour hours per lin. ft. or *vice versa.*

TABLE SHOWING SQUARE FEET PER CUBIC FOOT AND CUBIC FEET PER 100 SQUARE FEET FOR TIMBER OF VARIOUS THICKNESSES

Thickness of timber in inches	*Square feet per cubic foot*	*Cubic feet per* 100 *sq. feet*	*Thickness of timber in inches*	*Square ft. per cubic foot*	*Cubic feet per* 100 *sq. feet*
½	24	4·17	2½	4·80	20·83
¾	16	6·25	2¾	4·36	22·93
1	12	8·33	3	4	25·00
1¼	9·60	10·41	3¼	3·69	27·10
1½	8	12·50	3½	3·43	29·15
1¾	6·86	14·57	3¾	3·20	31·25
2	6	16·66	4	3	33·33
2¼	5·44	18·38			

TABLE SHOWING LINEAL FEET PER STANDARD OF 165 CUBIC FEET FOR TIMBER OF VARIOUS CROSS SECTIONS

Cross section of timber in sq. ins.	*Lin. ft. per standard*	*Cross section of timber in sq. ins.*	*Lin. ft. per standard*
2	11,786	21	1,131
3	6,600	24	994
4	5,893	27	880
5	4,755	30	793
6	3,966	36	660
7	3,395	40	595
8	3,000	45	528
9	2,640	48	495
10	2,377	54	440
11	2,159	60	396
12	1,980	66	360
15	1,585	72	330
18	1,320		

TIMBER—LIN. FEET PER STANDARD

1 standard timber = 165 cu. ft.
1 „ 9″ × 3″ walings = 882 lin. ft.
1 „ 10″ × 4″ „ = 598 „
1 „ 12″ × 6″ „ = 330 „
1 „ 4″ × 4″ struts = 1,500 „
1 „ 6″ × 6″ „ = 660 „
1 „ 7″ × 2″ runners = 1,833 „
1 „ 8″ × 1½″ poling boards = 1,990 „
1 „ 7″ × 1½″ „ „ = 2,260 „
1 „ 6″ × 1½″ „ „ = 2,660 „

TABLE SHOWING WEIGHT PER CUBIC FOOT IN LB. OF VARIOUS TIMBER

Timber	*Weight per cu. ft. in lb.*	*Timber*	*Weight per cu. ft. in lb.*
Ash	48	Pine, Oregon	35
Beech	50	„ Siberian	34
Birch	42	„ Yellow	28
Cedar	26	Poplar	30
Chestnut	36	Scots Fir	33
Deal	33	Spruce	30
Elm	38	Sycamore	41
Jarrah	58	Teak	48
Larch	38	Walnut	42
Mahogany	40	White Deal	30
Maple	46	Yew	44
Oak	50		

FIXING IRONMONGERY

	Description	*Unit*	*Carpenter hours*	*Labourer hours*
Hinges.	Fix 2″ butt hinges	per pair	0·70	—
„	„ 3″ „ „	„	1·00	—
„	„ 4″ „ „	„	1·20	—
„	„ 6″ cross garnet or tee-hinges	„	0·50	—
„	„ 12″ „ „ „ „	„	0·70	—
„	„ 18″ „ „ „ „	„	1·00	—
„	„ gate hinges (heavy)	„	1·80	1·80
Latches.	„ barrel bolts	each	0·40	—
„	„ gate latches	„	1·00	—
„	„ night „	„	1·70	—
„	„ rim „	„	0·80	—
Locks.	„ mortice locks	„	2·20	—
„	„ Norfolk „	„	2·50	—
„	„ padlock „	„	0·40	—
„	„ rimlocks „	„	1·20	—
„	„ Suffolk „	„	2·60	—
Fasteners.	„ casement fasteners	„	0·60	—
„	„ „ stays	„	0·50	—
„	„ cupboard fasteners	„	0·40	—
„	„ coat hooks	„	0·10	—
„	„ door handles	„	0·60	—
„	„ finger plates	„	0·20	—
„	„ hasp and staples	„	1·20	—

SECTION TWELVE

★

CONCRETOR

Concrete is now used extensively in all kinds of works of civil engineering and its cost per cubic yard varies considerably for different classes of work. It may be either mixed by hand or by machine, but hand mixing is to be avoided if at all possible for anything but very small quantities. Concrete mixing machines are available in all sizes from as small as 5/3½ cubic feet upwards, the 5/3½ meaning that the drum of the machine into which the aggregate, sand and cement are put will hold 5 cubic feet of the dry material and deliver 3½ cubic feet of the mixed concrete. These small machines are now used to a great extent for all works requiring a small output of concrete such as small foundations, beds and haunchings to pipes, etc., whilst the larger sizes are used on larger work requiring the bigger outputs. Concreting by machine is not only more economical and quick but has the added advantage of ensuring that the concrete is properly mixed with no cement loss and that the water content, so important in producing sound concrete, can be correctly gauged.

Aggregates and Sand

Various aggregates are used for concrete generally with a proportion of sand. Gravel, shingle, ballast and sand, broken stone, granite, limestone, etc., are all used, also broken bricks and clean furnace clinker. The last two do not produce the strong concrete which the others do. It is the general practice for all good class work to use the other aggregates and clean-washed sand. Ballast containing sand is now used a great deal, this sand content being controlled at the pit by grabbing from separate heaps of aggregate and sand, whence it is loaded direct into the lorries which deliver the material to the site of the works.

In the case of concrete work requiring really first-class concrete, it is usual to deliver the stone and sand separately, where it is off-loaded behind the concrete mixers and is then correctly gauged in gauge boxes in the ratio specified and placed in the machines for mixing.

The Material Cost of one cubic yard of Concrete

In calculating the cost of concrete per cubic yard, so far as the materials are concerned, the voids in the aggregate have to be considered. All aggregates and sand have an appreciable percentage of voids in them, these ranging from 40% to 50%. The cement and sand when mixed wet forms a mortar which goes to fill these voids, binding the aggregate together. From this it will be seen that in order to produce a cubic yard of mixed concrete a volume of aggregate, sand and cement considerably in excess of this has to go into it. The first of the tables beginning on page 126 shows the amount of aggregate, sand and cement required per cubic yard for various proportions of mix. The cement required is shown in tons, but the aggregate and sand is shown in cubic yards. The reason for this is that weight does not then enter into it as volumes are always constant. Had they also been shown in tons, variation in their cube measurement would occur due to their varying weight. In some districts aggregate and sand are sold per ton, and if this is so the price per cubic yard must be calculated for use with the table. On page 131 is shown a table giving the weights per ton of the most generally used aggregates.

The Water required per cubic yard of Concrete allowing for its Cost

The water used must be clean and free of organic matter. It is sometimes possible to lay on water from a tap adjacent to the mixer but in other cases water may have to be pumped into water carts or tanks on lorries and hauled to the site, and this can cost quite a lot per cube yard depending on the length of haul. Approximately 20 gallons of water are required to mix one cubic yard of concrete, but in actual practice considerably more than this is used, as such factors as waste, washing down the plant, mixers, lorries, dumpers, etc., must be taken into consideration and an allowance of three times the amount required for the concrete should be allowed for, viz. 60 gallons.

If the water has to be paid for, assuming it comes from a main through a meter, its cost per cube yard should be allowed for. A general "rule of thumb" figure for this is one penny per cubic yard. If, however, the water cannot be taken off a tap near the mixer, and has to be loaded to tanks and hauled by lorries to the mixers, this costs considerably more than one penny per cubic yard and must certainly be allowed for. On an aerodrome contract it was found that it was actually cheaper to lay 400 yards of 1″ water piping underground (in order to preserve it from frost) from a main to the mixer than to haul by lorry and tank, both methods having been tried out and costed. These are shown to illustrate that the water supply question can be a costly matter and is of the first importance and should be considered when estimating and also when deciding upon the position of the concrete mixing plant.

Note.—For methods of allowing for the cost of water on a contract, see page 16.

Cost of Laying 400 *yards of* 1 *inch Water Pipe*

Cost of laying 400 *yds. of* 1 *in. water pipe laid as temporary water service—total cube yds. concrete to be laid* 5,000

		£	s.	d.
Excavate trench by mechanical excavator and refill	400 lin. yds. at 1/6	30	0	0
Supply and lay 1 in. water barrel (water barrel was buried and not recovered)	400 lin. yds. at 2/6	50	0	0
Pay for connection to main and meter charge	.. .. ..	2	0	0
Cost of water: 300,000 gallons at 1/- per 1,000	.. .. ..	15	0	0
		£97	0	0

$$\therefore \text{Cost of water per cu. yd. of concrete} = \frac{£97}{5{,}000}$$

$$= 4{\cdot}60 \textit{ pence. per cu yd.}$$

Cost of Hauling Water

Cost of hauling water by lorry and tanks filled from a river $1\frac{1}{2}$ *miles away—total cu. yds. of concrete to be laid* 5,000

Total gallons to be hauled: 60 × 5,000 = 300,000 gallons
Gallons hauled in each lorry load = 400 „

$$\therefore \text{Total number of lorry trips of water} = \frac{300{,}000}{400}$$

= 750 trips, each of which took 42 minutes or 0·70 hours, pumping the water and hauling and running off into a tank adjacent to the mixers.

$\therefore$ Total lorry hours = 750 × 0·70 = 525

As concrete was mixed and placed at 8 cu. yds. per hour, requiring 8 × 60 = 480 gallons of water per hour, only 1 lorry was required this hauling 520 gallons per hour.

$\therefore$ *Cost of water haulage for* 300,000 *gallons.*

		£	*s.*	*d.*
Lorry and driver	525 hours at 7/6 ..	196	17	6
Pump hire (serviced by the lorry driver) ..	say 525 hours at 1/-	26	5	0
	Total ..	£223	2	6

$$\therefore \text{Cost of water per cu. yd. of concrete} = \frac{£223\ 2s.\ 6d.}{5{,}000}$$

= 10·70 pence per cu. yd.

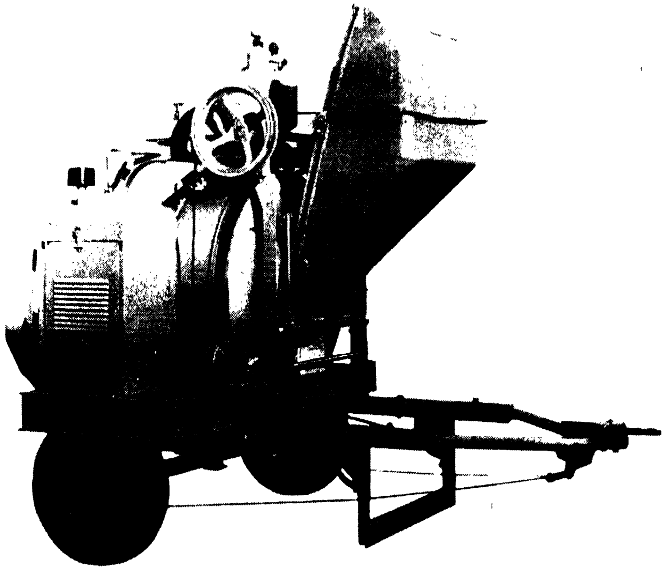

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FIG. 7.—STANDARD SUPER SEVEN VICTORIA MIXER FITTED FOR ROAD TRANSPORT

Concrete Mixing Plant

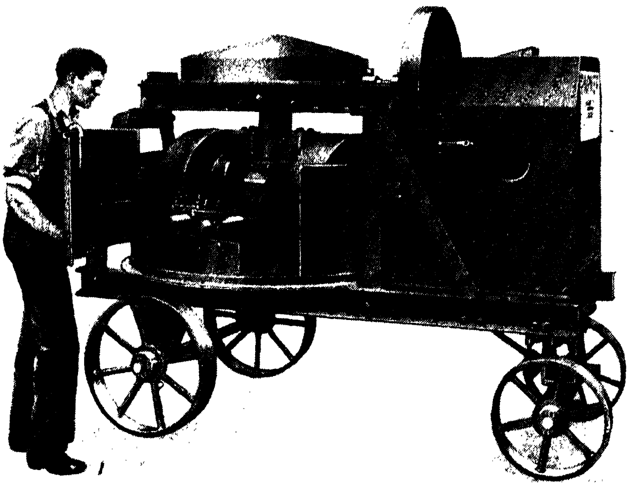
Concrete mixing plant consists of three main types:

1. The revolving drum type fitted with a loading hopper actuated by a clutch.
2. The continuous mix type.
3. The central mixing or Batcher Plant type.

The latter two types are only used on works requiring a large output such as large roads, aerodrome runways, etc.

THE DRUM AND HOPPER TYPE.—These machines are made in various sizes but the most generally used are the 5/3½, 7/5, 10/7 and 14/10, these giving outputs of mixed concrete of 3½, 5, 7 and 10 cubic feet per mix. It is necessary that the correct size of mixer be used for constructing different classes of work. It is most uneconomical, for instance, to use a large concrete mixer capable of producing 7 cubic yards of concrete per hour if it is only possible to lay half this amount in the class of work to be concreted. Thus one would use a 7/5 mixer, say, to produce the concrete required for haunching small diameter sewers but a larger type for concreting a large floor. In order to work these mixers tables are shown under Section Eight which give the correct apportionment of labour to each size of mixer in order to produce its proper maximum output at minimum cost. This correct balance of labour to plant is of the utmost importance, if concrete is to be placed in the work at competitive cost.

CONCRETE BATCHING PLANT AND CONTINUOUS MIX TYPE OF MIXERS.—These are only used where large outputs of mixed concrete are required. They have to be set up and their haulage and erection may cost quite a considerable sum. Assuming this sum to be in the region of £100 the haulage and erection cost per cubic yard of mixed concrete is small if the volume of concrete required is large, such as 5,000 cubic yards, but it will be appreciated that the cost per yard would be out of all proportion if the volume required was only 500 cubic yards. They are ideal machines to use on large road works, aerodromes, sea walls, mass concrete or similar works requiring big volumes of concrete easily and quickly placed. Their output varies from 10 cu. yds. upwards per hour per machine and both types are usually fitted with hoppers into which the materials required for the concrete are loaded by mechanical grab or dragline. These aggregates are then fed to the mixer.



Frederick Parker Ltd.

FIG. 8.—"OVEROLL" CONCRETE MIXER

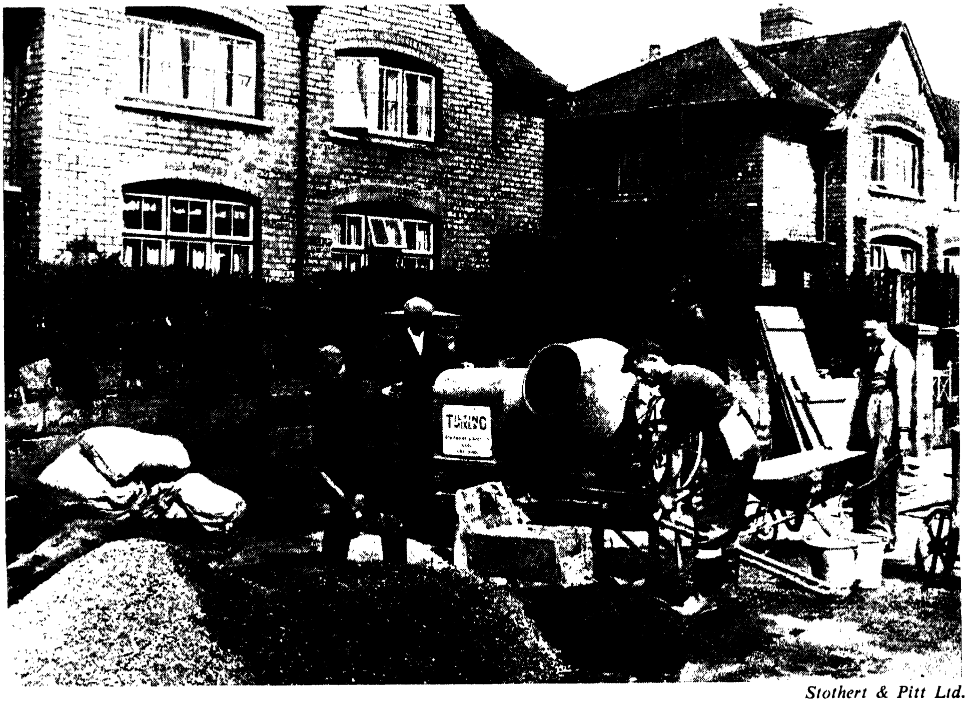
The concrete when mixed is, in turn, fed into a hopper and is then fed from the hopper direct to the lorries, dumpers, wagons or whatever type of haulage plant is being used for its transport. In this way the lorries have very little standing time at the mixers. The continuous type machine works rather on the principle of a sausage machine, in that it is continuously fed and the mixed concrete comes out in an unbroken flow.

The labour required to work these plants is small and a usual make-up is as follows:

Mixing .. .. 1 mixer and mixer driver.
1 mechanical grab.
2 men on cement, number depends on size of mixers.
1 man on hopper controlling the aggregate.
1 ,, ,, ,, ,, concrete.
1 ,, attending grab, water, etc.

Placing .. .. 2 men placing in the work per 10 cu. yds. output per hour.
(*in roads, runways, etc.*) 2 men tamping, if on roads, etc. ,, ,, ,,
1 man fixing expansion jointing and bullnosing the edges of the concrete per 10 cu. yds. output per hour.
2 men fixing side screeds per 10 cu. yds. output per hour.

This set up can place 10 cubic yards of concrete per hour and so far as the placing is concerned if 20 cubic yards output of concrete per hour is obtained from the mixing plant the work would have to be constructed on two faces with one unit of the above labour at each.



Stothert & Pitt Ltd.

FIG. 9.—TILTING MIXER AS WORKING AT SITE

Estimating the Cost per cubic yard

With this type of plant the estimator must allow for:

1. The haulage, erection and dismantling of the plant.
2. The mixing and placing cost.
3. The transporting cost.

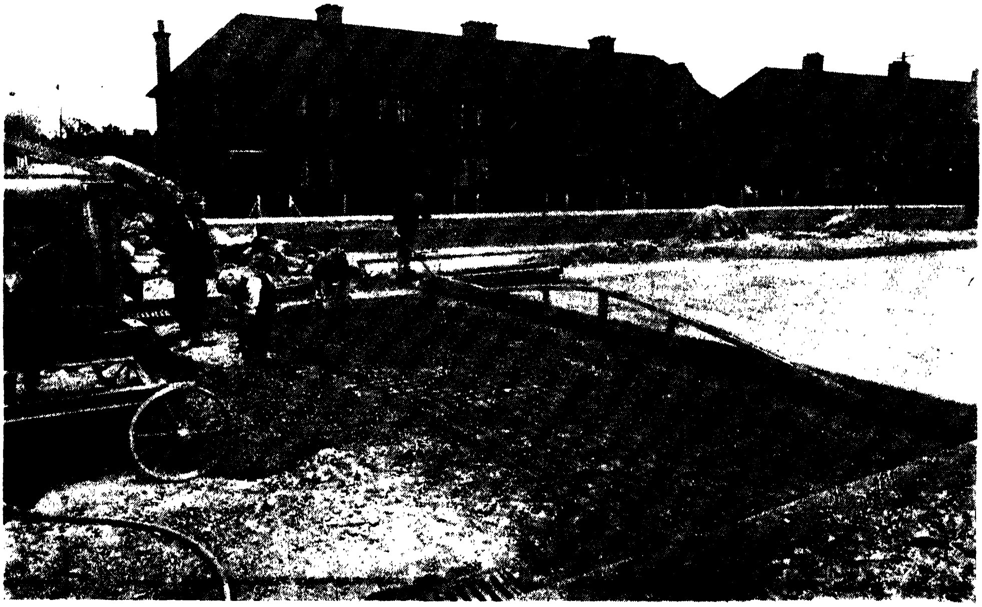
In connection with the concrete, the cost per cubic yard for haulage and erection is worked out on these lines:

> Assuming 6,000 cu. yds. have to be placed and the haulage cost of the plant to and from the site has been assessed at say £30, whilst it has been computed that to erect it will cost £40 and to dismantle £30, i.e. a total of £100.
>
> $$\text{Cost per cu. yd. to haul, erect and dismantle} = \frac{£100}{6{,}000} = 4d.\ \text{per cu. yd. approx.}$$

Tables are shown at the end of this Section for mixing and placing only, using machines of 10, 15, 20, 25 and 30 cubic yards output per hour each. The transporting is shown for the machines of different output under different tables to various lengths of haul, whilst multipliers are shown for various types of work carried out.

The total estimated cost per cubic yard therefore, is the sum of:

1. The haulage, erection and dismantling cost per cubic yard.
2. „ mixing and placing only cost. Per cubic yard.
3. „ transporting cost. „ „ „
4. „ cost of water for mixing. „ „ „



British Reinforced Concrete Engineering Co. Ltd.

FIG 10.—NORTH CIRCULAR ROAD, SHOWING SPACER MEMBER IN POSITION, THE CONCRETE FOUNDATION IS 10 IN. THICK, AND THE SURFACE IS OF ASPHALT

The Plant Cost per cubic yard of Concrete

How to calculate the working cost per hour of the various sized concrete mixers is clearly shown in the Section devoted to "Plant Working Cost per Hour". This cost should include the machine hire per hour, allowing for all running costs, in the way of driver's wages, fuel, oil, etc., the machine hire per hour rate, allowing for all depreciation, repairs and renewals. Plant hire firms usually hire out plant at so much per hour plus driver's wages, the hirer supplying all fuel and oil, and in the case of firms who possess their own plant they generally have a tabulated list of their plant showing its hiring rate per hour; these rates the estimator uses for tendering purposes. (See "Plant: Working Cost per Hour", Section Twenty.)

Concreting using Concrete Mixing Plant

In estimating for concrete work using Concrete Mixing Plant several important points have to be considered, these being:

1. The output of a concrete mixer varies depending on the class of work being concreted.
2. The output of a mixer from which the concrete is wheeled away in barrows is not so great as when the concrete is hauled away by mechanical transport such as lorries, dumpers, etc., as filling small barrows takes considerably longer than the larger vehicles.
3. The output of a concrete mixer is increased if it is loaded by mechanical plant as compared with hand loading, such loading being usually carried out by grabs, draglines, shovels, etc.
4. Whenever possible a mixer should be selected whose output is suitable for the class of work which has to be concreted.
5. It is not economical to use mechanical transport with concrete mixers of small output, as the plant used for transport has to stand too long while it is loaded with consequent large transport costs.
6. In the case of Central Mixing Plants the question of the cost of erecting and dismantling the mixers must be taken into account.

Since concrete can be mixed by hand or machine of various outputs per hour and can be transported by various means, such as by barrows, lorries, dumpers, wagons and locomotives, etc., and since the lengths of haul and classes of work concreted vary, it will be appreciated that many combinations must be considered and the correct combination of Mixing and Transporting Plant must be employed to carry out the work if it is to be done economically.

Data submitted for estimating purposes must therefore be such that the estimator has before him data from which the correct combination of Mixing Plant and Transporting Plant can be selected to build up his price, and this tabulated matter must be clear and concise in order that no undue difficulty is experienced in selecting the correct data for the case under consideration.

The Tables shown, clearly state in every case:

1. The nature of the work concreted.
2. The method by which the concrete mixer is loaded, whether by hand or mechanical plant.
3. The means employed to transport the concrete from the mixing plant to the site where it has to be placed, i.e. whether wheeled in barrows or transported in lorries, dumpers, etc.

The estimator, knowing the class of work which has to be concreted and the site conditions, must decide on the following before building up his price:

1. The type and size of concrete mixer he will use for the class of work which has to be concreted.

   Note.—Under the various tables for mixing and placing concrete the mixer hours to produce one cubic yard of concrete are shown for the different types of mixers and for various classes of concrete work. These tables may be used as a guide for selecting the most suitable size of mixer to use on the work in question.
2. Whether the mixer is loaded by hand or mechanical plant.
3. Whether the concrete is wheeled away in barrows or transported in mechanically propelled vehicles such as lorries, dumpers, etc.

Having decided on this he must then select the appropriate tables shown in order to build up his price.

Three operations have to be carried out in concreting work, viz.:

1. The concrete has to be mixed.
2. It has then to be transported or/and hoisted or lowered to where it has to be placed in the work.
3. The concrete has finally to be placed in the work.

One set of Tables is shown for "Mixing and Placing the Concrete only" while subsequent tables are shown for carrying out the other operations of "Transporting", "Hoisting" or "Lowering". By using these tables all combinations of concreting are available for the types of Mixing Plant and Transporting Plant shown.

Tables for Use in Estimating

In order that the cost of Concreting per cubic yard may be estimated for any combination of mixing plant, method of loading the mixing plant and transporting the concrete, the following tables have been included:

1. Mixing and Placing Concrete only to various classes of work, the concrete being mixed by hand.
2. Mixing and Placing Concrete only, the concrete being mixed by mixers of the Drum and Hopper Type, loaded by hand and the concrete wheeled away in barrows.
3. Mixing and Placing Concrete only, the concrete being mixed by mixers of the Drum and Hopper Type, loaded by hand and the concrete transported by mechanical plant, such as lorries, dumpers, and wagons and locomotives.
4. Mixing and Placing Concrete only, the concrete being mixed by mixers of the Drum and Hopper Type, loaded by mechanical plant such as grabs, etc., and the concrete transported by mechanical plant such as lorries, dumpers, wagons and locomotives.
5. Mixing and Placing Concrete only, using mixers capable of large outputs, loaded by mechanical plant, and concrete transported by mechanical plant, such as lorries, dumpers, etc.
6. Mixing and Placing Concrete only to floors, landings, roofs or tunnels where the concrete has to be hoisted or lowered. Mixers loaded by hand.
7. Mixing and Placing Concrete only in Moulds for Precast Concrete work. Mixers loaded by hand.
8. Wheeling only concrete in barrows.
9. Transporting only concrete in lorries, dumpers and by wagons and locomotives.
10. Hoisting or lowering only, concrete to floors, landings, roofs and tunnels, by hand.

11. Hoisting or lowering only, concrete to floors, landings, roofs and tunnels by crane or hoist.
12. Table of Multipliers for concreting floors, walls, etc., to slope or curve.
13. Fixing Reinforcement and Steelwork in concrete. Flat sheets, round bars, etc.
14. Off-loading and Fixing Precast Concrete Manholes.
15. Sundry Works to concrete.

The Tables for Mixing and Placing the Concrete Only

The Tables show the Plant and Labour Hours, or in the case of hand-mixed concrete, the Labour Hours only, to mix and place one cubic yard of concrete in the work. These hours multiplied by the prevailing Plant and Labour Rates give the cost of "Mixing and Placing the Concrete only" to which must be added the cost of wheeling, transporting, hoisting or lowering, etc.

The Tables for Transporting the Concrete only

Concrete may be transported from the mixing plant to the site where deposited in one or two ways, viz.:

1. By barrows or dobbin carts wheeled by hand.
2. By mechanically propelled vehicles such as lorries, dumpers, and wagons and locomotives.

In the case of (1), a Table is shown on page 138 which gives the labour hours per cubic yard wheeling concrete in barrows and dobbin carts.

Regarding Mechanical Transport, it should be noted that the time the vehicle is engaged in transporting one load of concrete is the sum of:

1. The time it stands whilst it is being loaded.
2. The time it takes to travel to the site where the concrete has to be deposited, off-load the concrete and return to the mixing plant ready for the next load.

The time of loading the vehicle per cubic yard is shown under the various Tables for "Mixing and Placing Concrete only" for the mixer hours shown represent the time the vehicle stands whilst one cubic yard of concrete is loaded into it. The time taken to haul to various lengths of haul, using lorries and dumpers and the time taken to haul a set of wagons using locomotives is shown on p. 138, so that the estimator by using these latter tables in conjunction with the "Mixing and Placing Concrete only" tables can calculate the mixing transporting and placing cost of the concrete per cubic yard for all combinations of mixers, class of work concreted, type of transport used and length of haul. The method of calculating this cost is best illustrated by example, and to do so, two examples are shown, one where the concrete is transported by lorry, and the other where locomotive Decauville wagons are used.

Example No. 1

Calculate the cost of Mixing, Transporting and Placing Concrete in a road the length of haul being a distance of one mile away from the Mixing Plant, the following being the particulars:

Concrete Mixer Used	10/7 Hopper-loading Mixer loaded by hand. Working Cost inclusive of Driver, Fuel, Oil, etc.	5/6 per hour
Lorries Used	5 ton Mechanical Tipping Lorries, Working Cost per hour inclusive of Driver, Fuel, Oil, etc.	8/- „ „
	Labour Rate	2/- „ „

Mixing and Placing

From the Table shown on page 133 the "Mixing and Placing Only" cost is:

Mixer hours per cubic yard	0·25	at 5/6 =	16·00 pence/cu. yd.
Labourer hours per cubic yard	2·00	at 2/- =	48·00 „ „

Transporting Concrete

In considering the number of vehicles required to transport the concrete the *Actual Number* as distinct from the *Theoretical Number* must be allowed for.

$$\text{Theoretical Number of vehicles required} = \frac{\text{Time to load} + \text{Time of Haul}}{\text{Time to load}}.$$

The actual number required is that to the nearest round vehicle in excess of the theoretical number.

In the case of this example, referring to the table shown on p. 138:

The cu. yds. of concrete hauled per load in a 5 ton lorry = 3 cu. yds. Since the concrete mixer hours per cu. yd. of concrete is 0·25 hours:

Time to load = 3·00 cu. yds. × 0·25 hours = 0·75 hours.

Referring to the table shown on p. 138:

Time taken by lorry to haul the concrete per round trip to a length of haul (one way) of one mile = 0·27 hours.

$$\therefore \text{Theoretical number of lorries required} = \frac{0{\cdot}75 + 0{\cdot}27}{0{\cdot}75}$$

$$= 1{\cdot}36.$$

∴ Actual number of lorries required = 2.

∴ Total cost to mix, haul and place one cu. yd. of concrete is:

10/7 concrete mixer = 0·25 hours at 5/6 per hour = 16·50 pence/cu. yd.
Lorry transport = 2 @ 0·25 hours = 0·50 hours at 8/- per hour = 48·00 pence/cu. yd.
Labour = 2·00 hours at 2/- per hour = 48·00 pence/cu. yd.

= 112·50 pence/cu. yd.

Example No. 2

Calculate the cost per cubic yard to concrete a road, the length of haul being one mile distant from the mixing plant using Decauville wagons hauled by locomotive on 2 ft. gauge track to transport the concrete, using a 10/7 mixer loaded by grab, the following being the particulars:

10/7 Mixer.	Working cost inclusive of driver, fuel, oil, etc.	5/6	per hour
Grab.	Working cost inclusive of driver, fuel, oil, etc.	12/-	„ „
Locomotive, wagons and rails.	Working cost inclusive of driver, fuel, oil, etc.	10/-	„ „
	Labour Rate	2/-	„ „

The number of Wagons per set

By correctly assessing the number of wagons per set, in conjunction with the output of the mixer and length of haul, one set of wagons is being filled whilst the other is being hauled.

Referring to the table shown on page 138, it will be seen that the time taken by locomotive to haul to a tip a mile distant is 0·62 hours per trip.

Referring to the table shown on page 133, it will be seen a 10/7 mixer by grab in concreting roads produces one cubic yard of concrete in 0·19 hours.

∴ in 0·62 hours it will produce $\frac{0\cdot62}{0\cdot19}$ or 3·26 cubic yards of concrete.

∴ sufficient wagons per set must be used to haul 3·26 cubic yards of concrete, say 4 No. cubic yard wagons.

Mixing and Placing Concrete

From tables shown on page 133 the "Mixing and Placing only" cost is:

Mixer hours per cubic yard	0·19	at	5/6	12·54 pence/cu. yd.
Grab hours per cubic yard	0·19	at	12/-	27·36 ,, ,,
Labourer hours per cubic yard	1·54	at	2/-	36·96 ,, ,,

Transporting Concrete

Locomotive cost to haul 3·26 cu. yds. = 0·62 hours at 10/-
= 74·40 pence

∴ Cost to haul one cubic yard .. .. = $\frac{74\cdot40}{3\cdot26}$ = 22·82 ,, ,,

∴ Total cost to haul and place concrete .. .. .. 99·68 ,, ,,

Note.—In connection with the above the cost of hauling, laying and removing track, locomotive, etc., must be taken into account.

The Tables for Hoisting or Lowering the Concrete only

The tables are shown for hoisting or lowering concrete by hand using such tackle as hand winches, jack rolls, etc., and also using mechanical plant such as cranes, and hoists.

In this connection it should be noted that if the concrete has to be transported as well as hoisted or lowered the cost of both operations must be allowed for.

Tables are also shown for:

1. The materials required for 1 cubic yard of mixed concrete for various proportions of mix.
2. The materials required for 1 cubic yard of cement mortar for various proportions of mix.
3. The tons per cubic yard and cubic yards per ton of the most common aggregates used.
4. The volume of concrete per lineal yard required to haunch and surround pipes of various diameters.
5. The volume of concrete per lineal yard required in bedding and haunching to kerb. See page 206.
6. The output in cubic yards per hour of various sized mixers.
7. The number of labourers to use with various sizes of concrete mixers in carrying out different classes of work. This is shown under Section Eight, page 65.

The latter table should prove a useful guide to those in charge of the construction of the work, as the balancing of the labour to the plant has been carefully worked out and tried out in order to achieve maximum output at minimum cost.

Note.—For table showing aggregate sand and cement required per cu. yd. of concrete, see page 126.
For table showing cement mortars, see page 127.

CUBIC YARDS OF AGGREGATE AND SAND, AND TONS OF CEMENT REQUIRED TO MAKE 1 CUBIC YARD OF CONCRETE OF VARIOUS MIXES

Note.—The data shown refers to "Dry Sand." Allow for Bulkage due to water content as follows:

Water Content Per Cu. Ft. *Lbs.*	*Bulkage*
3	1·24
4	1·25
5	1·26
6	1·27

Mix			*Aggregate cu. yds.*	*Sand cu. yds.*	*Cement tons*
Aggregate	*Sand*	*Cement*			
2	1	1	0·76	0·38	0·42
3	1	1	0·90	0·30	0·32
3	1½	1	0·80	0·40	0·29
3⅓	1⅔	1	0·82	0·41	0·26
4	2	1	0·84	0·42	0·22
5	2	1	0·90	0·36	0·20
5	2½	1	0·88	0·44	0·19
5	3	1	0·84	0·50	0·18
6	2½	1	0·94	0·39	0·17
6	3	1	0·90	0·45	0·16
7	2½	1	0·96	0·34	0·15
7	3	1	0·92	0·40	0·14
7	4	1	0·88	0·88	0·50
8	3	1	0·96	0·36	0·13
8	4	1	0·90	0·45	0·12
9	4	1	0·90	0·40	0·11
10	5	1	0·84	0·42	0·10
12	6	1	0·80	0·40	0·07

TABLE SHOWING CUBIC YARDS OF BALLAST CONTAINING SAND AND TONS OF CEMENT REQUIRED TO MAKE 1 CUBIC YARD OF CONCRETE OF VARIOUS MIXES. (BALLAST 2 OF STONE TO 1 OF SAND.)

Note.—The data shown refers to "Dry All in Ballast." Allow for Bulkage due to water content as follows:

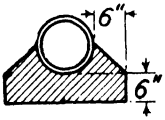
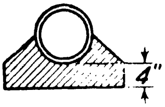
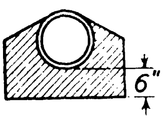
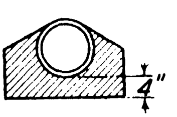
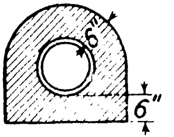
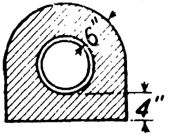
Water Content Per Cu. Ft. *Lbs.*	*Bulkage*
3	1·18
4	1·20
5	1·21
6	1·22

Mix		*Ballast containing sand cu. yds.*	*Cement tons*
Ballast and sand	*Cement*		
3	1	1·14	0·42
4	1	1·16	0·32
5	1	1·22	0·26
6	1	1·26	0·22
7	1	1·28	0·20
8	1	1·32	0·18
9	1	1·35	0·16
10	1	1·32	0·14
11	1	1·34	0·13
12	1	1·35	0·12
13	1	1·33	0·11
14	1	1·30	0·10
15	1	1·26	0·10
16	1	1·24	0·09
17	1	1·22	0·08
18	1	1·20	0·07

Note.—Tables showing volume in cubic yards per lineal yard of excavation and concrete for Kerb laid on various thicknesses and widths of concrete will be found on page 206.

CONCRETE TO PIPES. CUBIC YARDS PER LINEAL YARD

Note.—Concrete 6″ wider a side than outside diameter of pipe and 4″ and 6″ thick under pipes. Pipes surrounded with concrete 6″ thick.

	Diameter of pipes in inches and volume of concrete in cu. yds. per lin. yd.															
Concrete cross section	4″	6″	9″	12″	15″	18″	21″	24″	27″	30″	33″	36″	39″	42″	45″	48″
	0·10	0·11	0·14	0·17	0·21	0·25	0·30	0·34	0·38	0·44	0·50	0·54	0·58	0·62	0·66	0·70
	0·07	0·08	0·11	0·13	0·17	0·20	0·25	0·28	0·32	0·37	0·43	0·46	0·50	0·53	0·57	0·62
	0·12	0·14	0·17	0·21	0·25	0·30	0·34	0·38	0·44	0·50	0·55	0·61	0·67	0·73	0·80	0·86
	0·10	0·11	0·14	0·17	0·21	0·25	0·29	0·32	0·38	0·43	0·48	0·53	0·59	0·64	0·71	0·78
	0·18	0·20	0·28	0·36	0·42	0·51	0·60	0·65	0·73	0·80	0·85	0·90	0·95	1·03	1·10	1·20
	0·16	0·17	0·25	0·32	0·38	0·46	0·55	0·60	0·67	0·73	0·78	0·82	0·87	0·94	1·01	1·12

CEMENT MORTARS

Cubic yards of sand and cement required to make 1 cubic yard of mortar of various mixes

Note.—Allow for mixing cement mortar labour 6·00 hours per cu. yd.
The data shown relating to sand refers to dry sand. If washed sand is used a multiplier of 1·25 should be used in conjunction with the quantities of sand shown to allow for bulkage due to the moisture content.

Mix		*Sand cu. yds.*	*Cement tons*
Sand	*Cement*		
1	1	0·73	0·79
1½	1	0·93	0·67
2	1	1·00	0·54
2½	1	1·07	0·46
3	1	1·10	0·39
3½	1	1·15	0·33
4	1	1·20	0·29

Concreting, Mixing and Placing Concrete only by hand

Note.—(1) The hours shown are for "Mixing and Placing the Concrete only" per cubic yard. The concrete being mixed by hand.

(2) For wheeling in barrows, see page 138.

(3) For hoisting or lowering, see pages 136, 137.

(4) For sundry works to concrete, see page 140.

(5) For placing concrete in roofs, floors, landings and tunnels, see page 135.

(6) For placing concrete in roofs, floors, walls, etc., to slope or curve, see page 136.

(7) For erecting and striking formwork, see Section No. 11.

(8) For fixing reinforcement or steelwork, see pages 139 and 140.

Concreting by hand, mixing and placing only. (The hours shown do not allow for wheeling, or transporting, hoisting or lowering, see Notes above)	*Mixing and placing only*	
	Unreinforced	*Reinforced*
	Labourer hours per cubic yard	*Labourer hours per cubic yard*
Concrete to beams and girder casings cross sectional area up to—		
24 sq. inches	12·30	13·80
24 to 48 ,,	10·80	12·20
48 to 72 ,,	9·70	11·00
72 to 96 ,,	8·80	10·00
96 to 120 ,,	8·30	9·40
120 to 144 ,,	8·00	9·00
over 144 ,,	7·80	8·80
Concrete to braces cross sectional area up to—		
24 ,,	14·80	16·30
24 to 48 ,,	12·80	14·20
48 to 72 ,,	11·70	13·00
72 to 96 ,,	10·80	12·00
96 to 120 ,,	10·30	11·40
120 to 144 ,,	10·00	11·00
over 144 ,,	9·80	10·80
Concrete to columns, piers and pilasters cross sectional area up to—		
24 sq. inches	13·70	15·20
24 to 48 ,,	11·90	13·30
48 to 72 ,,	11·00	12·30
72 to 96 ,,	9·90	11·10
96 to 120 ,,	9·40	10·50
120 to 144 ,,	9·10	10·10
over 144 ,,	8·90	9·90
Concrete to small areas, paths, yards, etc.	4·80	5·30
Concrete to large areas, yards, roads, etc.	4·40	4·90
Concrete to beds, haunches and surrounds to pipes in open trenches up to 18 in. diameter	6·80	7·50
Concrete to beds, haunches and surrounds to pipes in open trenches over 18 in. diameter	6·20	6·80
Concrete to foundations to chambers, manholes, etc.	4·80	5·30
Concrete to mass foundations	4·40	4·90
Concrete to foundations in narrow trenches such as normal building foundations, beds and backing to kerb, etc.	5·00	5·50
Concrete to walls up to 6 in. thick	7·80	10·20
,, ,, ,, 6 to 9 ,, ...	6·80	8·40
,, ,, ,, 9 to 12 ,, ...	6·00	7·00
,, ,, ,, over 12 ,, ...	5·40	6·00

Concreting, Mixing and Placing only. Concrete Mixed by Concrete Mixers of the Drum and Hopper type sizes: 5/3½, 7/5 and 10/7 Mixers loaded by hand and the Concrete wheeled away by hand in barrows

Note.—(1) The Plant and Labour hours shown are for mixing and placing the concrete only per cubic yard,

(2) The Mixer Output in cubic yards per hour is *not* so great as when the concrete is removed and transported by mechanical plant such as lorries, as the time in filling barrows from the mixer is much slower.

(3) For wheeling the concrete in barrows, see page 138.

(4) For hoisting or lowering, see pages 136, 137.

(5) For sundry works to concrete, see page 140.

(6) For placing concrete in roofs, floors, landings and tunnels, see page 135.

(7) For concreting to roofs, floors, etc., to slope or curve, see page 136.

(8) For erecting and striking formwork, see Section No. 11.

(9) For fixing reinforcement or steelwork, see pages 139 and 140.

(10) If concrete is reinforced use a Multiplier of 1·10 with the Plant and Labour hours shown.

Class of work concreted (The hours shown do not allow for wheeling, hoisting or lowering, etc., see Notes above)	*Type of Mixer used and Plant and Labourer hours mixing and placing only, per cubic yard*					
	5/3½		7/5		10/7	
	Plant hours per cu. yard	*Labourer hours per cu. yard*	*Plant hours per cu. yard*	*Labourer hours per cu. yard*	*Plant hours per cu. yard*	*Labourer hours per cu. yard*
Concrete in beams, girder casings cross sectional area—½ to 1 sq. ft.	1·00	6·00	0·83	5·81	0·66	5·28
1 to 2 ,, ...	0·90	5·40	0·75	5·25	0·60	4·80
2 to 3 ,, ...	0·81	4·86	0·68	4·76	0·54	4·32
over 3 ,, ...	0·78	4·68	0·65	4·55	0·52	4·16
Concrete to braces cross sectional area—						
½ to 1 sq. ft.	1·22	7·32	1·00	7·00	0·84	6·72
1 to 2 ,, ...	1·10	6·60	0·90	6·30	0·78	6·24
2 to 3 ,, ...	1·00	6·00	0·82	5·74	0·70	5·60
over 3 ,, ...	0·96	5·76	0·80	5·60	0·68	5·44
Concrete to columns, piers and pilasters cross sectional area—						
½ to 1 sq. ft.	1·12	6·72	0·94	6·58	0·75	6·00
1 to 2 ,, ...	1·01	6·06	0·85	5·95	0·69	5·52
2 to 3 ,, ...	0·90	5·40	0·76	5·32	0·63	5·04
over 3 ,, ...	0·87	5·22	0·72	5·04	0·60	4·80
Concrete to small areas, paths, etc.	0·64	3·20	0·44	3·08	0·36	2·88
Concrete to large areas, roads, yards, etc.	—	—	0·40	2·80	0·33	2·64
Concrete to beds, haunches and surrounds to pipes in open trenches up to 18 in. diameter	0·90	4·50	0·60	4·20	0·45	3·60
Concrete to beds, haunches and surrounds to pipes in open trenches over 18 in. diameter ..	0·80	4·00	0·54	3·78	0·40	3·20
Concrete to foundations of chambers, manholes, etc.	0·66	3·30	0·45	3·15	0·38	3·04
Concrete to mass foundations	—	—	0·40	2·80	0·33	2·64
Concrete to foundations in narrow trenches such as normal building foundations, beds and backing to kerb, etc.	0·70	3·50	0·50	3·00	0·40	2·80
Concrete to walls up to 6 in. thick	0·98	5·88	0·78	5·46	0·63	5·04
,, ,, ,, 6 to 9 ,, ...	0·84	5·04	0·66	4·62	0·55	4·40
,, ,, ,, 9 to 12 ,, ...	0·74	4·44	0·58	4·06	0·48	3·84
,, ,, ,, over 12 ,, ...	0·64	3·84	0·52	3·64	0·44	3·52

Concreting, Mixing and Placing only. Concrete mixed by Concrete Mixers of the Drum and Hopper type, sizes 7/5, 10/7 and 14/10. Mixers loaded by hand and the Concrete transported by mechanically propelled vehicles such as Lorries, Dumpers, Decauville Wagons and Locomotives, etc.

Note.—(1) The Plant and Labour hours shown are for mixing and placing the concrete only per cubic yard.

(2) The mixer output in cubic yards per hour is greater than when the concrete is wheeled away in barrows as the loading of the concrete to large vehicles is much quicker than placing it in small handbarrows.

(3) For transporting the concrete in lorries, dumpers, etc., see page 138.

(4) For hoisting and lowering, see pages 136, 137.

(5) For sundry works to concrete, see page 140.

(6) For concreting to roofs, landings, floors and tunnels, see page 135.

(7) For placing concrete in roofs, floors, or walls to slope or curve, see page 136.

(8) For erecting and striking formwork, see Section No. 11.

(9) For fixing reinforcement or steelwork, see pages 139 and 140.

(10) If the concrete is reinforced use a Multiplier of 1·10 with the Plant and Labour hours shown.

Class of work concreted (The hours shown do not allow for transporting, hoisting or lowering, etc., see Notes above)	*Type of Mixer used and Plant and Labourer hours mixing and placing only per cu. yd.*					
	7/5		10/7		14/10	
	Plant hours per cu. yard	*Labourer hours per cu. yard*	*Plant hours per cu. yard*	*Labourer hours per cu. yard*	*Plant hours per cu. yard*	*Labourer hours per cu. yard*
Concrete to Beams, girder casings cross sectional area—						
½ to 1 sq. ft.	0·60	4·20	0·50	4·00	0·42	3·78
1 to 2 „	0·53	3·71	0·44	3·52	0·37	3·33
2 to 3 „	0·48	3·36	0·40	3·20	0·34	3·06
over 3 „	0·46	3·22	0·38	3·04	0·32	2·88
Concrete to braces cross sectional area—						
½ to 1 sq. ft.	0·75	5·25	0·63	5·04	0·54	4·86
1 to 2 „	0·70	4·90	0·50	4·72	0·51	4·59
2 to 3 „	0·64	4·48	0·54	4·32	0·47	4·13
over 3 „	0·62	4·34	0·52	4·16	0·45	4·05
Concrete to columns, piers and pilasters cross sectional area—						
½ to 1 sq. ft.	0·66	4·62	0·56	4·48	0·48	4·32
1 to 2 „	0·61	4·27	0·52	4·16	0·45	4·05
2 to 3 „	0·57	3·99	0·47	3·76	0·41	3·69
over 3 „	0·54	3·78	0·45	3·60	0·39	3·51
Concrete in small areas, paths, yards, etc.	0·33	2·31	0·28	2·24	0·24	2·16
Concrete in large areas, yards, roads, etc.	0·31	2·17	0·25	2·00	0·20	1·80
Concrete in beds, haunches and surrounds to pipes in open trenches up to 18 in. diameter	0·45	3·15	0·36	2·88	0·31	2·79
Concrete in beds, haunches and surrounds to pipes in open trenches over 18 in. diameter	0·40	2·80	0·33	2·64	0·28	2·52
Concrete to foundations to chambers, manholes, etc.	0·36	2·52	0·30	2·40	0·23	2·07
Concrete to mass foundations	0·30	2·10	0·25	2·00	0·20	1·80
Concrete to foundations in narrow trenches such as normal building foundations, beds and backing to kerb, etc.	0·40	2·40	0·32	2·24	0·24	2·16
Concrete to walls up to 6 in. thick	0·60	4·20	0·50	4·00	0·42	3·78
„ „ „ 6 to 9 „	0·51	3·57	0·42	3·36	0·36	3·24
„ „ „ 9 to 12 „	0·44	3·08	0·37	2·96	0·32	2·88
„ „ „ over 12 „	0·40	2·80	0·33	2·64	0·28	2·52

Weight of various aggregates. Tons per cu. yd. and cu. yds. per ton

Material	*Tons per cu. yd.*	*Cu. yds. per ton*
Ashes—clean	0·64	1·56
Ballast containing sand	1·25	0·80
Broken bricks	0·96	1·04
Cement	1·08	0·93
Chalk	1·66	0·60
Clinker—furnace clean	0·58	1·72
Coke breeze	0·50	2·00
Granite, broken 1½″–½″	1·08	0·93
,, ,, ¾″–⅛″	1·04	0·96
Limestone, ,, 1½″–½″	1·00	1·00
,, ,, ¾″–⅛″	0·96	1·04
Sand, pit	1·15	0·87
,, washed	1·20	0·83
Shale	1·04	0·96
Shingle, 1½″–½″	1·10	0·91
,, ¾″–⅛″	1·08	0·93

Note.—Sand tabulated in cu. yds. If price of sand is quoted in tons then cu. yd. cost of the sand must be calculated. Sand in the above table has been taken as weighing 1·20 tons, per cu. yard, therefore, if sand is quoted 10/- ton the cost per cu. yd. is 10/- × 1·20 = 12/- cu. yd.

For rendering to Brickwork, etc., see "Plasterer" section, p. 240.

Concreting Moulds for Precast Concrete Unit Work per cubic yard

In work of this kind costs per cubic yard vary greatly, depending on the volume contained per mould, the intricacy of the unit, etc. The cleaning down and oiling of the moulds is quite a costly matter and has been allowed for in the labour hours shown. Most engineers, if a large quantity of precast units are required on the job, purchase direct from an established firm who specialise in this class of work. Three examples are shown and the estimator must use his ingenuity to price any similar article, e.g. a lintel 9″ × 4″ would be comparable with a 10″ × 5″ kerb and so on. In general the cost increases as the volume held by the mould decreases and if moulds are really intricate, difficult to erect and strike, this also should be allowed for. The aim should be to produce a mould easy to erect, strike and clean.

The labour hours shown do not include wheeling or transporting, which must be added. (See table, page 138.)

Type of work (*these labours do not include wheeling or transporting*)	*By hand labour hrs. per cu. yd.*	*By mixer. Drum and hopper type. Size*					
		5/3½		7/5		10/7	
		Mixer hours	*L'bourer hours*	*Mixer hours*	*L'bourer hours*	*Mixer hours*	*L'bourer hours*
Concrete posts, 6′ long × 4″ × 4″ ..	22·70	0·66	21·20	0·40	21·00	0·30	20·90
,, kerbs, 3′ long × 10″ × 5″ ..	9·40	0·66	7·90	0·40	7·60	0·30	7·50
,, paving slabs, 2″ thick × 3′ × 2′	27·00	0·66	25·50	0·40	25·20	0·30	25·10

For shuttering for moulds for precast concrete units, see page 109.

For wheeling or transporting, see page 138.

Concreting with Concrete Mixers of the Drum and Hopper type, the Mixer being mechanically loaded

In concreting large areas, such as roads, mass foundations, or where a considerable output is required, it is common practice to use mixers of the drum and hopper type, these being mechanically loaded by Hi-lift shovels, grabs or draglines. The advantages of this are:

1. The cost per cubic yard of mixing the concrete is cheaper than by hand.
2. The output is increased.

This plant set-up can be used to advantage in concreting large areas such as roads, runways, factory floors, and so on.

Tables are shown for the output of concrete mixers of the 10/7, 14/10 and 21/14 class, fed either by hand or machines, as well as a table showing the plant and labour hours per cubic yard, for mixing and placing only. Transporting the concrete is shown under separate tables on page 138.

A table is also shown under Section Eight for the gang of men required to mix and place

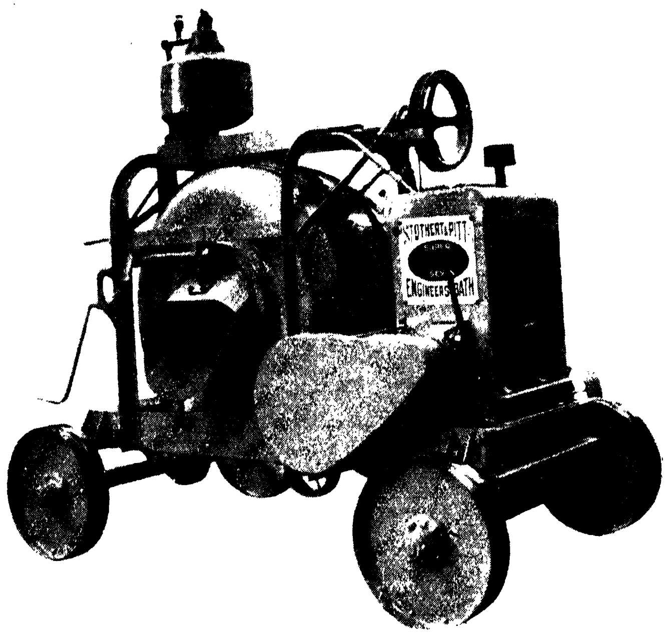


FIG 11. (above).—STANDARD SUPER SEVEN VICTORIA MIXER
Stothert & Pitt Ltd.

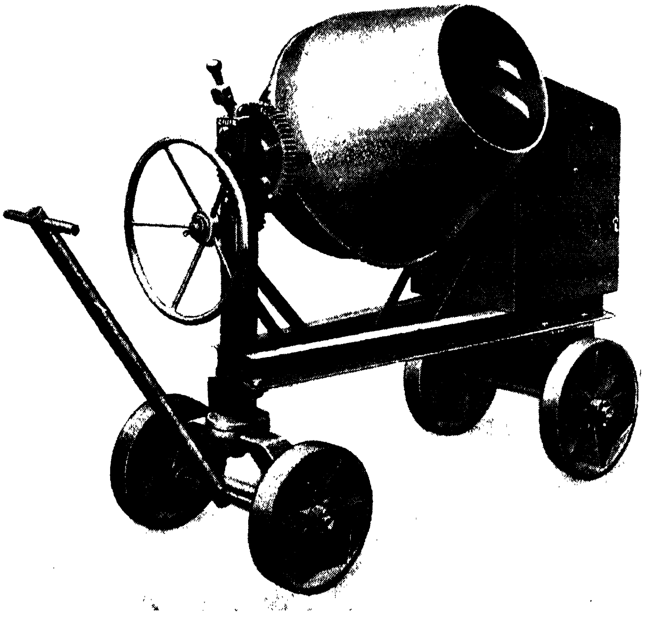


FIG. 12 (below).—"LITTLE GIANT" 5/3½ CONCRETE MIXER
Frederick Parker Ltd.

the concrete, for the various sizes of mixers, fed both by hand and by machine (See page 65).

Note.—For concreting with central batching plant or continuous type mixers, see pages 134, 135.

OUTPUT IN CUBIC YARDS PER HOUR OF MIXERS OF THE DRUM AND HOPPER TYPE LOADED BY HAND AND BY MACHINE

Method of loading mixer	*Size of mixers and type of work and output in cubic yards per hour*					
	10/7		14/10		21/4	
	Large areas or mass concrete	*Normal foundations*	*Large areas or mass concrete*	*Normal foundations*	*Large areas or mass concrete*	*Normal foundations*
By hand	4·00	2·66	5·00	3·75	7·00	5·80
„ Hi-lift shovel . .	4·80	3·20	6·00	4·50	8·40	7·00
„ dragline	5·00	3·36	6·25	4·70	8·64	7·20
„ grab	5·20	3·50	6·50	4·90	9·00	7·50

CONCRETING, MIXING AND PLACING ONLY, WITH MIXERS OF THE DRUM AND HOPPER TYPE, LOADED BY HAND AND MECHANICALLY, PER CUBIC YARD

Note.—(1) Transporting the concrete from the mixer to the site of the work is *not* included in this table. See page 138.

(2) The plant and labour hours per cubic yard shown under concrete to areas allow for all tamping, but not screeding, curing, or bullnosing edges.

10/7 *Concrete Mixer*

Plant and Labour	*Unit*	*Method of loading, type of work and plant and labour hours per cu. yd.*							
		By hand		*By Hi-lift shovel*		*By dragline*		*By grab*	
		Large areas or mass concrete	*Normal foundations*	*Large areas or mass concrete*	*Normal foundations*	*Large areas or mass concrete*	*Normal foundations*	*Large areas or mass concrete*	*Normal foundations*
Concrete mixer and driver	hrs/cu.yd.	0·25	0·30	0·21	0·31	0·20	0·30	0·19	0·29
Hi-lift shovel and driver	„	—	—	0·21	0·31	—	—	—	—
Dragline and driver . .	„	—	—	—	—	0·20	0·30	—	—
Grab and driver . .	„	—	—	—	—	—	—	0·19	0·29
Labourer	„	2·00	2·40	1·66	1·90	1·60	1·80	1·54	1·72

For reinforcement and sundry works to concrete roads, see pages 139, 140.

14/10 *Concrete Mixer*

Plant and Labour	*Unit*	*Method of loading, type of work and plant and labour hours per cu. yd.*							
		By hand		*By Hi-lift shovel*		*By dragline*		*By grab*	
		Large areas or mass concrete	*Normal foundations*	*Large areas or mass concrete*	*Normal foundations*	*Large areas or mass concrete*	*Normal foundations*	*Large areas or mass concrete*	*Normal foundations*
Concrete mixer and driver	hrs/cu.yd.	0·20	0·23	0·17	0·22	0·16	0·21	0·15	0·20
Hi-lift shovel and driver	„	—	—	0·17	0·22	—	—	—	—
Dragline and driver	„	—	—	—	—	0·16	0·21	—	—
Grab and driver	„	—	—	—	—	—	—	0·15	0·20
Labourer	„	1·80	2·07	1·50	1·56	1·44	1·50	1·39	1·50

For reinforcement and sundry works to concrete roads, see pages 139, 140.

21/14 *Concrete Mixer*

Plant and Labour	*Unit*	*Method of loading, type of work and plant and labour hours per cu. yd.*							
		By hand		*By Hi-lift shovel*		*By dragline*		*By grab*	
		Large areas or mass concrete	*Normal foundations*	*Large areas or mass concrete*	*Normal foundations*	*Large areas or mass concrete*	*Normal foundations*	*Large areas or mass concrete*	*Normal foundations*
Concrete mixer and driver	hrs/cu.yd.	0·14	0·18	0·12	0·15	0·12	0·14	0·11	0·13
Hi-lift shovel and driver	„	—	—	0·12	0·15	—	—	—	—
Dragline and driver	„	—	—	—	—	0·12	0·14	—	—
Grab and driver	„	—	—	—	—	—	—	0·11	0·13
Labourer	„	1·54	1·98	1·20	1·15	1·16	1·11	1·11	1·07

For reinforcement and sundry works to concrete roads, see pages 139, 140.

Concreting, Mixing and Placing only, using Mixers of Large Output. Where the Concrete is Transported by Mechanically-propelled Vehicles such as Lorries, Dumpers, Wagons and Locomotives, etc. Mixers loaded mechanically

Note —(1) The hours shown are for mixing and placing only per cubic yard.

(2) For transporting the concrete, see page 138.

(3) The plant and labour hours shown assume that the mixers are mechanically loaded by grab, dragline or other means thus the plant hours shown are those for both the mixer and the grab, or other type of plant loading mixer.

(4) The hours shown allow in the case of areas, for tamping but not for fixing side forms, curing or bullnosing the edges.

(5) In the case of Central Mixing Plants allowance must be made for erecting and dismantling the plant, see page 120.

(6) For sundry works to concrete, see page 140.

(7) For fixing reinforcement and steelwork, see pages 139 and 140.

Class of Works Concreted Mixing and Placing only *For transporting, see Notes)*	*Normal Output of Mixer in cubic yards per hour and Plant and Labour hours per cubic yard. Mixing and Placing only*											
	10		15		20		25		30		35	
	Plant hours per cu. yard	*Lab. hours per cu. yard*	*Plant hours per cu. yard*	*Lab. hours per cu. yard*	*Plant hours per cu. yard*	*Lab. hours per cu. yard*	*Plant hours per cu. yard*	*Lab. hours per cu. yard*	*Plant hours per cu. yard*	*Lab. hours per cu. yard*	*Plant hours per cu. yard*	*Lab. hours per cu. yard*
Large areas, roads, runways, etc. ..	0·10	1·20	0·066	1·00	0·050	0·90	0·040	0·84	0·033	0·74	0·029	0·68
Mass foundations ..	0·11	1·10	0·072	0·87	0·055	0·66	0·044	0·57	0·036	0·50	0·032	0.48
Mass walls ..	0·13	1·43	0·085	1·30	0·065	1·23	0·052	1·18	0·043	1·08	0·037	1·00

Concreting, Mixing and Placing only to Floors, Landings, Roofs and Tunnels, Mixers loaded by hand

Note.—(1) The hours shown are for mixing and placing the concrete only per cubic yard, and in the case of tunnels the hours shown are applicable for tunnels up to 50 feet long.

(2) For mixing and placing concrete in tunnels whose lengths are in excess of 50 feet use Table of Multipliers on page 136.

(3) For hoisting or lowering concrete to various heights or depths, see pages 136, 137.

(4) If the concrete has to be wheeled or transported from where mixed to where it has to be placed, this must be allowed for, see page 138.

(5) For erecting and striking formwork, see Section No. 11.

(6) For fixing reinforcement and steelwork, see pages 139 and 140.

(7) For mixing and placing concrete in walls, roofs, etc.,to curve and slope, see page 136.

Concreting, Mixing and Placing only. (For hoisting, lowering, wheeling and transporting, see Note above)	*Mixing and Placing only by hand. Labourers hours per cubic yard*	*Mixing and Placing only using Concrete Mixers of sizes shown*					
		7/5		10/7		14/10	
		Plant hours per cu. yard	*Labourer hours per cu. yard*	*Plant hours per cu. yard*	*Labourer hours per cu. yard*	*Plant hours per cu. yard*	*Labourer hours per cu. yard*
Concrete to floors, landings and roofs up to 4½ in. thick ..	8·40	0·75	5·25	0·62	4·96	0·54	4·36
4½ to 6 „ ..	8·00	0·72	5·04	0·60	4·80	0·50	4·50
over 6 „ ..	7·60	0·67	4·69	0·56	4·48	0·48	4·32
Concrete to beds, haunches and surrounds to pipes in tunnels up to 50 ft. long and pipes up to—							
18 in. diameter	10·00	0·84	6·72	0·67	6·03	0·57	5·70
over 18 in. diameter	9·20	0·75	6·00	0·61	5·49	0·52	5·20
Concrete in mass filling to tunnels up to 50 ft. long and of cross sections up to 24 sq. ft. ..	8·80	0·62	4·96	0·53	4·77	0·45	4·50
over 24 „ ..	8·00	0·56	4·48	0·48	4·32	0·40	4·00

HOISTING OR LOWERING CONCRETE BY HAND WHERE PLACED IN TUNNELS UP TO 50 FEET LONG

Height to which concrete is hoisted or lowered in feet	*Labourer hours per cubic yard*
10	1·00
20	1 50
30	2·10
40	2·80
50	3·60
60	4·50

Assumed to be carried out with such plant as jack roll, hand winch, etc.

SIZE OF MECHANICAL GRAB OR DRAGLINE TO USE TO FEED THE MIXERS

Mixer output. Cu. yds.	*Size of grab or dragline. Cu. yds.*
10	¼
15	⅜
20	⅜
25	½
30	½
35	½

TABLE OF MULTIPLIERS FOR USE WITH THE TABLES SHOWN FOR MIXING AND PLACING AND HOISTING OR LOWERING CONCRETE IN TUNNELS WHOSE LENGTH IS IN EXCESS OF 50 FEET

Length of Tunnel from Shaft in Feet	*Concrete Mixer and Labour hour Multipliers*
50	1·00
100	1·20
150	1·40
200	1·60
250	1·80
300	2·00

TABLE OF MULTIPLIERS FOR USE WITH THE CONCRETE MIXER AND LABOUR HOURS SHOWN FOR MIXING AND PLACING CONCRETE ONLY IN FLOORS, LANDINGS, ROOFS AND WALLS FOR CONCRETE PLACED TO SLOPE AND CURVE

Description	*Labourer Hours Multipliers*
Concreting floors, landings and roofs to slope	1·05
„ „ „ „ „ „ curve—slow sweep	1·15
„ „ „ „ „ „ curve—quick sweep	1·25
Concreting walls to slope	1·07
Concreting walls to curve	1·10

Hoisting or Lowering Concrete using Mechanical Plant such as Cranes or Hoists in Tunnels up to 50 feet long

In concreting below ground the quantity of concrete which can be placed in a given time is influenced by the nature of the work being carried out. In tunnel work, for instance, it is only possible to place a certain amount of concrete per hour, depending on the size and length of the tunnel. By referring to the tables shown for "Mixing and Placing Concrete Only" the estimator has available the mixer hours taken to produce 1 cubic yard of concrete for the class of work under consideration. A crane and skips capable of lowering 1 cubic yard of concrete in a similar number of hours, should therefore be used.

By referring to the Table shown for hoisting or lowering concrete by crane or by hoist, the plant, together with the size of skips to use can be found as well as the crane and labour hours per cubic yard for lowering the concrete.

It should be noted that in the example shown the mixer and crane hours happen to be the same, but in working out an actual case this may not be so. In selecting the crane or hoist to use in such a case, the estimator should select that whose hoisting or lowering hours per cubic yard most nearly approaches to and is not less than the mixer hours per cubic yard, and in allowing for the crane or hoist hours per cubic yard, should allow the *same hours as the Mixer hours.*

This point must be carefully noted for in some cases the mixer hours per cubic yard may be more than the crane or hoist hours shown in the table, this being due to the nature of the work being carried out; but since the crane is being employed on the work, it must be charged at the same hours as the mixer hours despite the fact that it is not working to capacity.

Example

A tunnel 30 feet below ground not exceeding 50 feet in length and of cross sectional area 2 square yards, has to be filled with mass concrete. It has been decided to use a 10/7 concrete mixer loaded by hand. Select the crane and skips to use and find the cost per cubic yard of concreting if:

The working cost or hire rate inclusive of Driver, Fuel and
Oil of Concrete Mixer and Crane .. .. = 6/- per hour.
Labour Rate .. .. = 2/- „ „

From Table showing Mixing and Placing Mass Concrete in Tunnels, page 135.

10/7 concrete mixer hours/cu. yd. = 0·53 hours and labour hours per cu. yd. = 4·77 hours.

Referring to the
Hoisting and Lowering by Crane Table, on this page.

An 8 cwt. Crane with 5 cubic feet skips lowers at the rate of 0·53 hours/cubic yard and would therefore be used.

The estimator would build up his price on the following lines:

Description of Operation	*10/7 Concrete Mixer Hours*	*8 cwt. Crane Hours*	*Labourer Hours*
Mix and place concrete only in tunnel	0·53	—	4·77
Lower 30 ft. below ground	—	0·53	0·53
Total hours per cubic yard	0·53	0·53	5·30

.Cost of concreting per cu. yard
10/7 Mixer = 0·53 hours at 6/- per hour = 38·16 pence per cu. yard
8 cwt. crane = 0·53 „ at 6/- „ = 38·16 „
Labour = 5·30 „ at 2/- „ = 127·20 „
Total cost per cubic yard = 203·52

HOISTING OR LOWERING CONCRETE USING HOISTS OR CRANES WHERE PLACED IN TUNNELS UP TO 50 FEET LONG

Size of Crane or Hoist required in Cwts.	*Depth of Shafts below Ground in Feet and the Crane or Hoist and Labour Hours per cubic yard*												
	Size of skips to use in cu feet	10		20		30		40		50		60	
		Plant hours per cu. yard	*Lab. hours per cu. yard*	*Plant hours per cu. yard*	*Lab. hours per cu. yard*	*Plant hours per cu. yard*	*Lab. hours per cu. yard*	*Plant hours per cu. yard*	*Lab. hours per cu. yard*	*Plant hours per cu. yard*	*Lab. hours per cu. yard*	*Plant hours per cu. yard*	*Lab. hours per cu. yard*
8	5	0·44	0·44	0·48	0·48	0·53	0·53	0·56	0·56	0·60	0·60	0·63	0·63
12–15	7	0·40	0·40	0·43	0·43	0·45	0·45	0·47	0·47	0·50	0·50	0·54	0·54
12–15	10	0·36	0·36	0·38	0·38	0·41	0·41	0·43	0·43	0·45	0·45	0·48	0·48
20	13½	0·33	0·33	0·35	0·35	0·37	0·37	0·39	0·39	0·41	0·41	0·43	0·43

TRAVELLING TIME TAKEN PER LOAD TO HAUL CONCRETE FROM THE POINT OF MIXING TO THE POINT OF OFF-LOADING, OFF-LOAD AND RETURN FOR THE NEXT LOAD, USING VARIOUS TYPES OF TRANSPORTING PLANT

Note.—(1) The hours shown are the average hours per round trip. They do *not* allow for the time the vehicle stands while it is being loaded.

(2) The lorry hours shown are based on vehicles fitted with mechanical tipping gear and assume the vehicles run on reasonably level firm surfaces.

(3) The hours shown for haulage by locomotives and wagons are per set of wagons.

Length of haul (one way)	*Type of transporting plant used and plant hours per load*					
	Horses and carts	*Lorries fitted with mech. tipping gear*	*Dumpers*	*Wheeled tractor-drawn wagons*	*Locomotives and wagons on 2 foot gauge Decauville track*	*Locomotives and wagons on 4 ft. 8½ in. gauge track*
100 yds.	0·12	0·09	0·10	0·10	0·16	0·19
200 ,,	0·15	0·10	0·12	0·11	0·20	0·23
220 ,,	0·16	0·11	0·13	0·12	0·22	0·25
300 ,,	0·17	0·12	0·14	0·13	0·24	0·28
400 ,,	0·22	0·13	0·18	0·14	0·27	0·30
440 ,,	0·25	0·14	0·19	0·16	0·28	0·32
500 ,,	0·28	0·15	0·20	0·17	0·30	0·34
660 ,,	0·34	0·16	0·23	0·18	0·35	0·40
880 ,,	0·43	0·18	0·26	0·21	0·40	0·46
1 mile	0·75	0·27	0·40	0·31	0·62	0·68
2 miles	1·50	0·41	—	0·47	0·94	1·10
3 ,,	—	0·54	—	—	—	—
4 ,,	—	0·67	—	—	—	—
5 ,,	—	0·79	—	—	—	—

SHOWING CU. YDS. OF CONCRETE HAULED PER LOAD BY VARIOUS TYPES OF TRANSPORTING PLANT

Note.—The data shown allows for normal filling of the vehicles concerned.

Type of transporting plant used	*Cubic yds. of concrete hauled per load*
Dumper	
2 cu. yds.	1·60
2½ ,,	2·00
3 ,,	2·40
Lorry	
1 ton	0·60
2 tons	1·20
3 ,,	1·80
4 ,,	2·40
5 ,,	3·00
6 ,,	3·60
Wagons	
½ cu. yd.	0·40
¾ ,,	0·60
1 ,,	0·80
2 cu. yds.	1·60
3 ,,	2·40
4 ,,	3·20
5 ,,	4·00

TRANSPORTING CONCRETE USING ORDINARY BARROWS OR TWO WHEEL HAND TIPPING DOBBIN CONCRETE BARROWS

Type of Plant used	*Labour hours per cubic yard wheeling concrete up to 25 yards run*
Steel barrows	0·80
Two wheel steel hand tipping Dobbin Concrete barrows. 6 cubic feet	0·60

PRECAST CONCRETE MANHOLES 42″ DIAMETER CHAMBERS

Labour, off-load and fix	*Lab. hours*	10/7 *mixer hrs.*
42″ precast concrete bottoms, each	4·80	—
42″ chamber rings, per lin. ft. . .	3·40	—
27″ ,, ,, ,, ,, ,, . .	1·70	—
42″ to 27″ tapers, each	4·00	—
6″ cover slabs, each	2·20	—
Concrete surround, per cu. yd. . .	4·80	0·25

Note.—Manhole parts assumed delivered to site by lorry.

REINFORCEMENT TO CONCRETE.

This may be either in flat sheets or bars, bent or otherwise and indented bars. The cost of fixing the latter is the same as for round bars.

FLAT SHEETS LAID IN VARIOUS CLASSES OF WORK PER SQUARE YARD

Weight in lbs. per sq. yard	*Unit*	*To Beams*	*To Columns*	*To Floors*	*To Girder Casings*	*To Roads*	*To Roofs*	*To Walls*
1	Lab. hours	0·12	0·14	0·03	0·18	0·02	0·06	0·10
2	,,	0·17	0·20	0·04	0·25	0·03	0·09	0·14
3	,,	0·22	0·26	0·05	0·32	0·04	0·12	0·18
4	,,	0·27	0·32	0·06	0·38	0·05	0·15	0·22
5	,,	0·32	0·38	0·07	0·44	0·06	0·18	0·26
6	,,	0·37	0·44	0·08	0·50	0·07	0·21	0·30
7	,,	0·41	0·50	0·09	0·57	0·08	0·24	0·34
8	,,	0·47	0·58	0·10	0·66	0·09	0·27	0·38

CUTTING FLAT SHEET REINFORCEMENT PER LIN. FOOT

Weight of sheets, lbs. per sq. yard	*Straight cutting, labour hours*	*Circular cutting, labour hours*
1	0·02	0·04
2	0·03	0·06
3	0·04	0·08
4	0·05	0·10
5	0·06	0·12
6	0·07	0·14
7	0·08	0·16
8	0·09	0·18

MULTIPLIERS FOR SHEET REINFORCEMENT LAID IN FLOORS OR ROOFS AT VARIOUS HEIGHTS ABOVE GROUND

Height above ground in feet	*Multiplier*
10	1·00
20	1·10
30	1·20
40	1·30

ROUND BAR REINFORCEMENT TO CONCRETE WORKS. FIXED COMPLETE LABOUR HOURS PER CWT.

Dia. of Bars	*Straight bars*						*Bent bars*					
	Walls		*Floors, roofs and beams*		*Columns and braces*		*Walls*		*Floors, roofs and beams*		*Columns and braces*	
	Steel fixer hrs.	*Lab. hrs.*	*Steel fixer hrs.*	*Lab. hrs.*	*Steel fixer hrs.*	*Lab. hrs.*	*Steel fixer hrs.*	*Lab. hrs.*	*Steel fixer hrs.*	*Lab. hrs.*	*Steel fixer hrs.*	*Lab. hrs.*
Up to ⅜″ . .	3·0	3·6	2·0	2·6	3·3	3·9	3·5	4·10	2·5	3·1	3·8	4·4
⅜″ and ½″ . .	1·7	2·3	1·2	1·8	2·0	2·6	2·3	2·9	1·7	2·3	2·6	3·2
½″ to ¾″ . .	1·4	2·0	1·0	1·6	1·7	2·3	1·9	2·5	1·5	2·1	2·2	2·8
Over ¾″ . .	1·10	1·6	0·70	1·30	1·3	1·9	1·5	2·1	1·2	1·8	1·8	2·40

SUNDRY WORKS TO CONCRETE

Description	*Unit*	***Labourer hours***
Concreting in very small quantities, such as to posts, etc.	cu. ft.	0·28
Cement washing	sq. yd.	0·25
Curing with hessian	,,	0·08
,, ,, paper (waterproof)	,,	0·08
,, ,, sand	,,	0·20
Distempering	,,	0·25
Fit expansion jointing	sq. ft.	0·15
Fix timber screed boards, straight	,,	0·25
,, steel side forms . . ,, ...	,,	0·16
,, timber ,, ,, to curves, slow sweeps	,,	0·40
,, ,, ,, ,, ,, ,, quick ,, ...	,,	0·60
Grout in rag-bolts up to 1″ diameter	each	0·33
,, ,, ,, including punching hole in brickwork	,,	0·70
,, ,, ,, ,, ,, ,, ,, concrete	,,	1·20
Hack face of concrete for key for rendering	sq. yd.	0·50
Round edges with bullnosed trowels	lin. ft.	0·04
Rubbing down with carborundum	sq. yd.	0·80
Running in "Elastite" or Mastic filling to expansion joint	lin. ft.	0·10
Screed and trowel surfaces	sq. yd.	0·40
Silicate of soda, per dressing	,,	0·02
Studded roller finish	,,	0·06
Tamping concrete surface with hand tampers	,,	0·12
,, ,, ,, ,, ,, ,, leather or canvas belt finish	,,	0·33

LABOUR HOURS TO ADD PER CWT. TO THE PREVIOUS TABLE IF BAR REINFORCEMENT IS HOISTED OR LOWERED

Depth hoisted or lowered in feet	*Labour hours to add per cwt. and diameter of bars*			
	Up to $\frac{3}{8}''$	$\frac{3}{8}''$ to $\frac{1}{2}''$	$\frac{1}{2}''$ to $\frac{3}{4}''$	*Over* $\frac{3}{4}''$
10	0·20	0·17	0·14	0·11
20	0·28	0·24	0·20	0·16
30	0·36	0·31	0·26	0·21
40	0·44	0·38	0·32	0·26
50	0·52	0·45	0·38	0·31

ROLLED STEEL JOISTS, CHANNELS, ETC., FIXED PER CWT.

Unit	*At ground level*	*Feet above or below ground level*				
		10	20	30	40	50
Lab. hours Plain joists etc.	1·00	1·30	1·35	1·40	1·45	1·50

Note.—For girder or cross beams with angle cleats use a multiplier of 2·00 with the labour hours shown.

SECTION THIRTEEN

★

EXCAVATION: EXCAVATOR ABOVE GROUND

This section deals with excavation carried out at ground level such as bulk and surface excavation as distinct from excavation carried out below ground, as in trenches, shafts and basements. Excavation below ground is the subject of the next section.

In considering the cost of excavation several factors have to be taken into account as these have a marked influence upon the cost. These factors are:

1. The nature of the site.
2. The type of excavation which has to be carried out.
3. The nature of the ground excavated, i.e. whether it is hard or soft, etc.
4. The bulkage of the ground after it is excavated as loaded for transport.
5. The method adopted of carrying out the excavation, i.e. whether by hand or by mechanical plant of various types and sizes.
6. The prevailing weather conditions during which the excavation is carried out.

The data shown for purposes of estimating takes such factors into account and represents a "fair average" for normal works of excavation.

In transporting excavated material the bulkage of the material concerned must be taken into account, since this is reflected in transport costs, the estimator being only concerned with the solid cubic yards of material excavated. In the tables shown setting out the cubic yards of material hauled per load by various types of vehicles normal bulkage of the material has been allowed for, the amount shown being the solid cubic yards hauled per load allowing for bulkage and normal heaping of the loads.

Mechanical plant is now extensively used to carry out excavation where the volume is such that its use is merited and where the nature of the work is such that suitable plant can be employed. In considering the use of mechanical excavating plant it should be noted that such plant is capable of excavating all normal grounds such as top soil, sand, loam, clay, gravel, etc. It is not capable, however, of excavating rock in solid beds. If the volume of excavation merits its use mechanical excavation should be adopted for in so doing excavation is carried out at a fast rate of progress and at low cost.

Economical Length of Haul of Transport Vehicles

The use of the correct type of transport vehicles to haul excavated material is important, for the economical length of haul of different types of transporting plant is variable. In order to illustrate this, two graphs are shown, one referring to excavation carried out by hand and the other to excavation carried out mechanically.

The graphs show the cost of excavating and transporting sand various forms of transport being used in each case. The costs shown denote the comparative costs of excavating and hauling to tip, attendant labour being allowed for as follows:

1. Excavation carried out by hand in conjunction with horses and carts, lorries or dumpers, a total of 3 No. men digging and loading per vehicle.

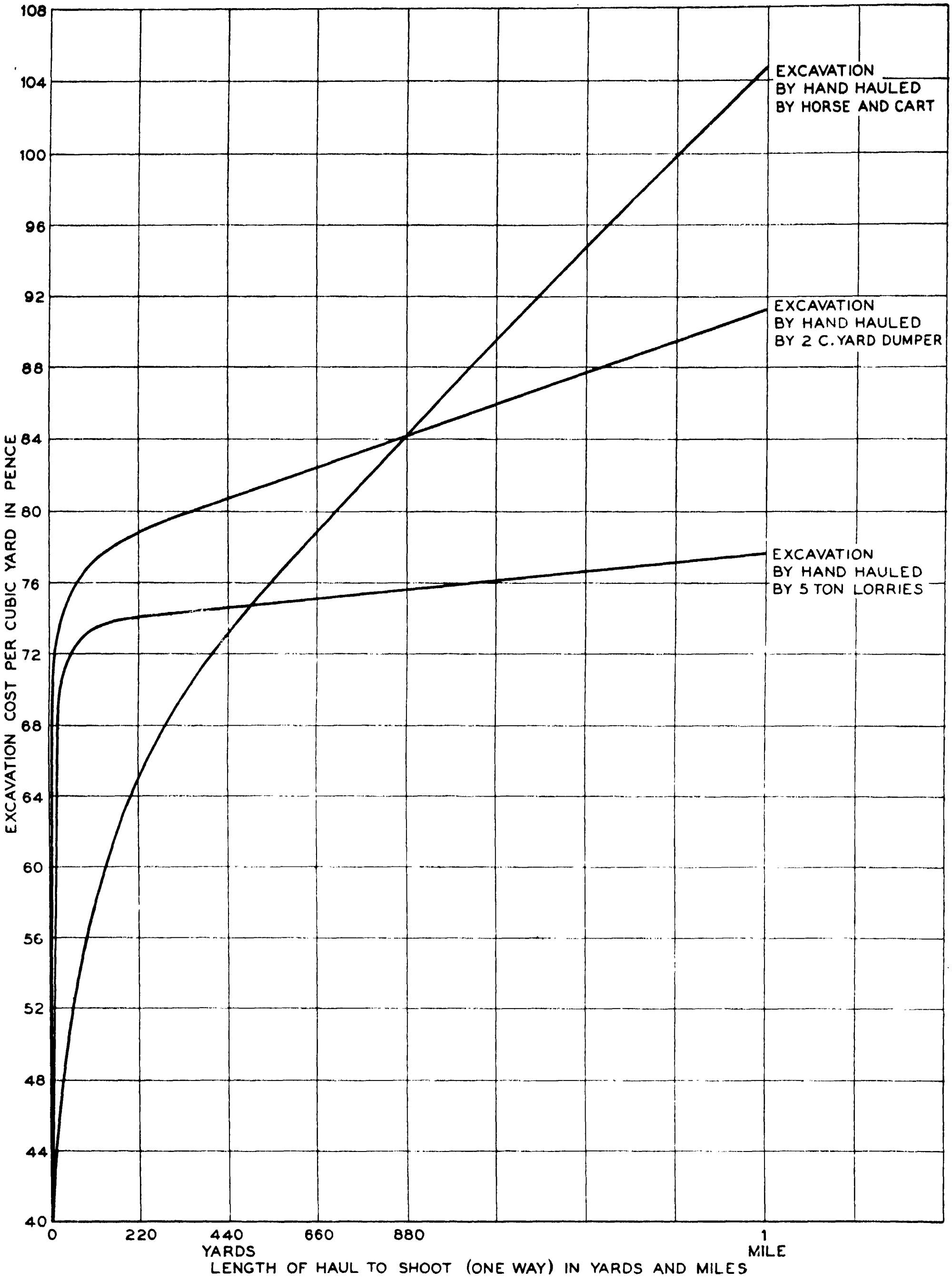


FIG. 13.—GRAPH SHOWING THE COMPARATIVE COSTS OF EXCAVATION CARRIED OUT BY HAND IN FIRM SAND, THE MATERIAL BEING HAULED BY VARIOUS TYPES OF VEHICLES TO VARYING LENGTHS OF HAUL

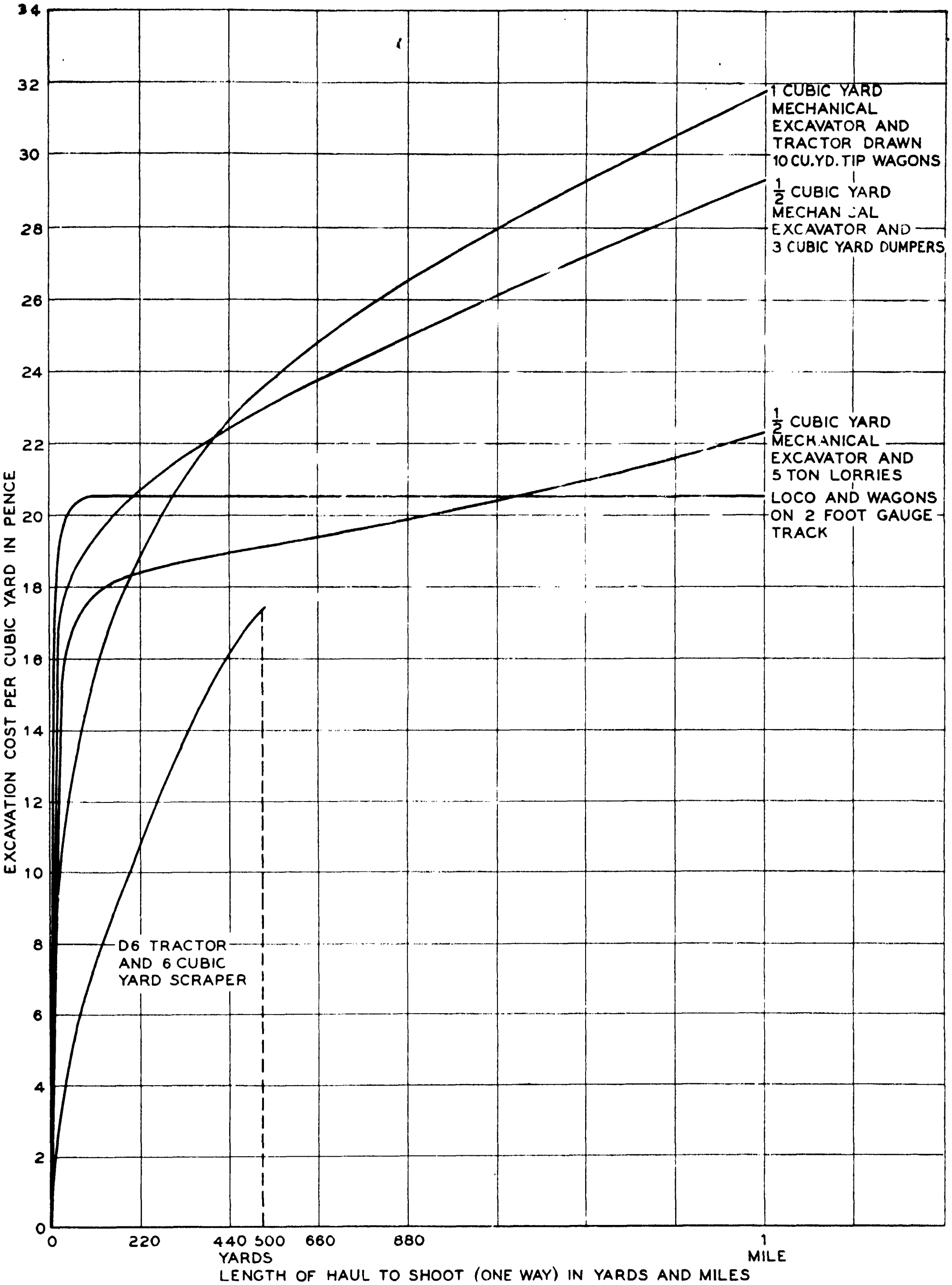


FIG. 14.—GRAPH SHOWING THE COMPARATIVE COSTS OF EXCAVATION CARRIED OUT BY VARIOUS TYPES OF MECHANICAL EXCAVATING PLANT, THE GROUND EXCAVATED BEING FIRM SAND, THE EXCAVATED MATERIAL BEING HAULED TO VARIOUS LENGTHS OF HAUL BY DIFFERENT TYPES OF HAULAGE PLANT

2. Excavation carried out by ½ cu. yd. mechanical excavator with skimmer equipment in conjunction with 5 ton lorries or 3 cu. yd. dumpers, 1 No. banksman, 2 men trimming the formation, and 1 No. man on the tip, a total of 4 men.
3. Excavation carried out by ½ cu. yd. mechanical excavator with skimmer equipment in conjunction with locomotive and wagons, running on 2 ft. gauge rail track, 1 man in attendance on the locomotive, 2 No. men on track maintenance, 2 No. men trimming formations, and 2 No. men on the tip, slewing track, etc., a total of 7 men.
4. Bulk excavation carried out by a 1 cu. yd. mechanical excavator with skimmer equipment in conjunction with tractor-drawn 10 cu. yd. tip wagons: 2 No. men trimming formations and 2 No. men on the tip, a total of 4 men.
5. Excavation carried out by D6 tractor and scraper: 1 No. man in attendance.

The graphs are produced from the appropriate data shown in the relevant estimating tables, the ground being firm sand in each case. In order to calculate the costs for plotting purposes the following basic rates for the hire rate or working cost of the plant and labour per hour are assumed, the plant rates being inclusive of driver, fuel and oil:

Horse, cart and driver	5/-	per hour
5 ton lorry	8/-	„
2 cu. yd. dumper	8/4	„
3 cu. yd. dumper	9/-	„
1/2 cu. yd. mechanical excavator	12/6	„
1 cu. yd. mechanical excavator	17/6	„
Locomotive and wagons, including hire of rail track ..	10/-	„
D6 tractor and 10 cu. yd. wagons..	25/-	„
D6 tractor and 6 cu. yd. scraper	30/-	„
Labour rate	2/-	„

By studying these graphs the following is observed:

Excavation Carried Out by Hand

1. Excavation transported by horse and cart is suitable for lengths of haul up to but not in excess of 500 yds. The excavation cost rises rapidly on lengths of haul in excess of this, and haulage by lorries is then more economical.

2. Excavation transported by lorries fitted with mechanical tipping gear is more costly than by horse and cart on lengths of haul up to 500 yds. On lengths of haul in excess of this, excavation in conjunction with lorries is considerably cheaper.

3. Dumpers are generally expensive to use, excavation transported by them being more costly than by either horse and cart or lorry. They have the advantage, however, of being able to travel on rough ground or on sites which are wet and muddy on which horse or lorry transport could *not* run, and for this reason are used to a large extent. The length of haul for which they are best suited is up to 440 yds. Under really wet conditions on open sites they are almost indispensable.

Excavation carried out by Mechanical Excavating Plant

1. Excavation carried out by mechanical excavators in conjunction with lorries fitted with mechanical tipping gear is suitable for all lengths of haul and is cheaper than where dumpers are used. Dumpers can, however, run on rough ground or on open wet sites unsuitable for lorries, and under such conditions are extensively used.

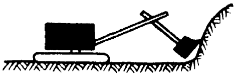
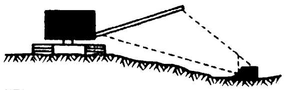
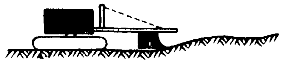
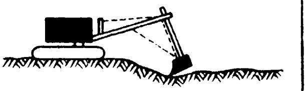
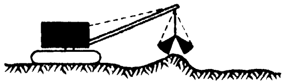
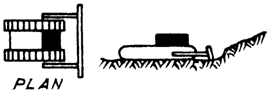
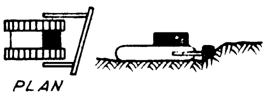
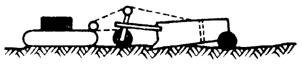
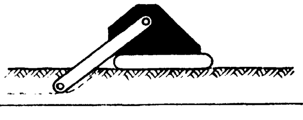
TYPE	ELEVATION	TYPE OF EXCAVATION SUITABLE FOR
FACE SHOVEL		FOR CUTTINGS OR BANKS GREATER THAN 5 FT HIGH. CAN DIG HARD GROUND AND SOFT ROCK.
DRAGLINE		FOR EXCAVATION BELOW THE LEVEL OF ITS TRACKS. CLEARING DITCHES STREAMS ETC. HAS WIDE DUMPING RANGE AND LONG REACH.
SKIMMER		FOR EXCAVATION DOWN TO LEVEL OF ITS TRACKS NOT OVER 5 FT DEEP SUCH AS AREAS OF EXCAVATION OVER NEW ROADS ETC.
BACKACTER		FOR EXCAVATION OF TRENCHES AND SMALL AREAS OF EXCAVATION BELOW GROUND.
GRAB		FOR LOADING OR UNLOADING. DIGGING LOOSE MATERIALS AND PLACING IN HEAPS.
BULLDOZER	 	FOR FILLING AND GRADING PUSHES UP TO 100 LIN YARDS.
ANGLE DOZER	 	FOR FILLING AND GRADING PUSHES UP TO 100 LIN YARDS. BLADE CAN BE SQUARED FOR USE AS A BULLDOZER.
TRACTOR AND SCRAPER		FOR EXCAVATING LARGE AREAS LEVELLING AND GRADING. USED FOR EARTH EXCAVATING AND MOVING AND TIPPING FROM 50 TO 500 YARDS.
ENDLESS BUCKET TYPE TRENCH EXCAVATOR		FOR EXCAVATING TRENCHES. ENDLESS CHAIN OF BUCKETS ON BOOM. CUTS GROUND AND LEAVES A CLEAN TRENCH EXCAVATION.

FIG. 15.—MECHANICAL PLANT FOR USE IN MOVING EARTH. SHOWING TYPE OF WORK FOR WHICH IT IS SUITABLE

2. Excavation carried out by mechanical excavators, using locomotives and wagons running on rail track to haul the excavated material, is a cheap form of excavation, provided the quantity of excavation to be carried out merits the use of this form of transport. The cost shown by the graph does not include the cost of laying and afterwards removing the track. This cost may be considerable, and the cost of the excavation per cu. yd. including this cost should be carefully considered before deciding to base the estimate on this form of transport.

3. Excavation carried out by large mechanical excavators in conjunction with tractor-drawn tip wagons of large capacity is a cheap form of excavation on short lengths of haul, being cheaper than lorries or dumpers. The length of haul should, if possible, not exceed 300 yds., as with hauls in excess of this the cost rises rapidly. On the longer hauls, lorries should be used if the site conditions make this possible.

4. Excavation by tractor and scraper on work for which it is suitable is an exceedingly cheap form of excavation on lengths of haul up to 500 yds. If the length of haul is in excess of this, mechanical excavators and lorries should be used, or, if the nature and volume of the work is such that it is suitable for elevating graders this type of plant may be used.

5. Excavation carried out by mechanical plant is considerably cheaper than hand excavation. If the volume to be excavated merits it and the nature of the work is such that it can be carried out mechanically, excavating plant should be used.

Tables shown for Estimating Purposes

Since excavation may be carried out by hand or by mechanical plant, the excavated material being transported to various lengths of haul in vehicles of different types and sizes, data submitted for estimating purposes must be such that the necessary data are available from which to "build up" an estimate for any suitable combination likely to be met with.

With this in view the various operations involved in carrying out excavation are tabulated under separate tables, and by correctly using these the excavation cost per cubic yard for any combination may be computed.

Various detailed examples are shown throughout this section illustrating the method of "building up" excavation costs which demonstrate the manner in which this is done.

Excavation carried out by Hand

Excavation by hand is generally associated with vehicles, such as barrows, hand-propelled wagons or horses and carts as the means of transporting the excavated material, such forms of transport being suitable for comparatively short lengths of haul.

Excavation by hand, however, may also be carried out, using mechanical transport such as lorries, but it should be noted that in using such plant the transporting cost is likely to be high, since the vehicle stands for a long period of time while it is being loaded.

Handbarrows are suitable for lengths of wheel up to 25 lin. yds.; horses and carts up to 500 lin. yds.; dumpers up to ¼ mile and lorries to any range.

In order to illustrate the method of estimating the cost of hand-excavated material, two examples are shown.

Example No. 1.—Calculate the cost per cu. yd. of bulk excavation in loamy soil carried out by hand, the excavated material being loaded into barrows and wheeled and tipped at a 25 yd. run, the prevailing labour rate being 2/- per hour.

From the table shown on p. 148

Labour hours excavating and loading bulk loamy soil per cu. yd. .. = 1·00 hrs.

From the table shown on p. 157

Labour hours wheeling loamy soil in barrows to a 25 yd. run per cu. yd. = 0·64 hrs.
∴ Total labour hours per cu. yd. .. .. = 1·64 hrs.
∴ Cost per cu. yd. = 1·64 hrs. at 2/- per hr. = 39·36 pence per cu. yd.

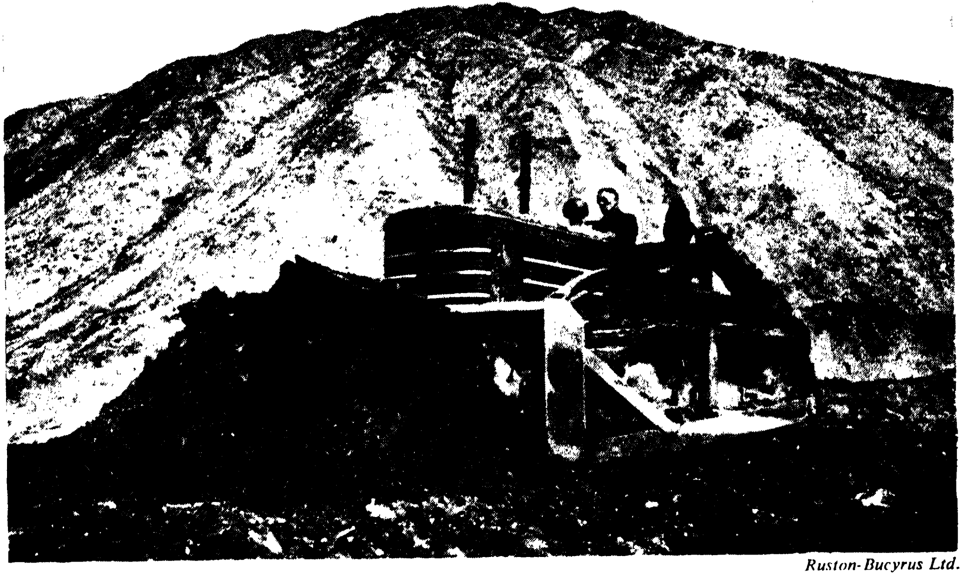


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FIG. 16.—BULLDOZER LEVELLING MUCK ON FILLING

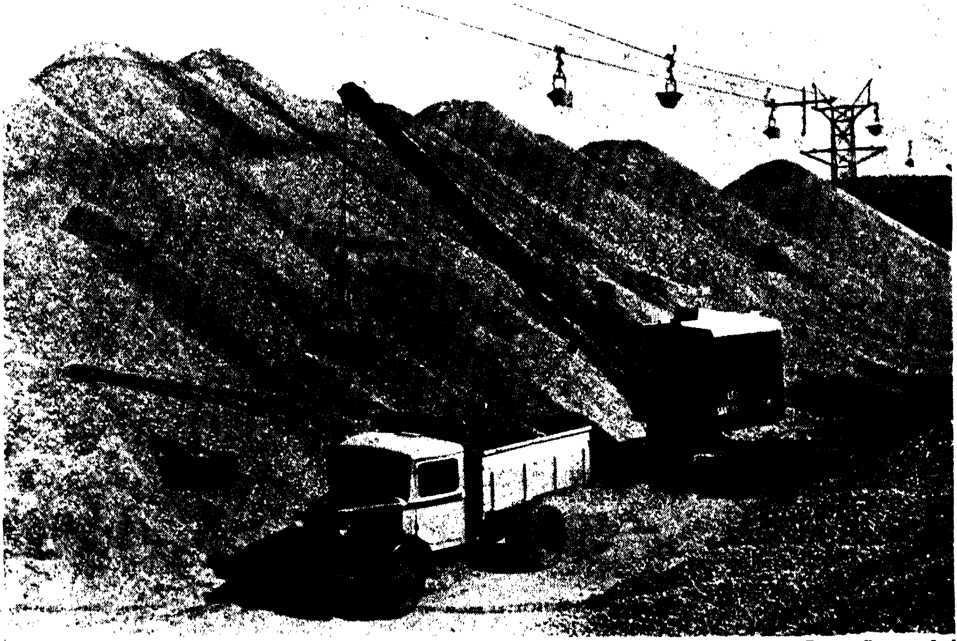

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FIG. 17.—EXCAVATOR FITTED WITH A GRAB, FILLING A LORRY WITH BALLAST

EXCAVATION CARRIED OUT BY HAND

Note.—(1) The hours shown are for excavating and loading only, and do not allow for wheeling or transporting, for which see p. 157.

(2) The vehicles referred to are vehicles such as horses and carts, lorries, dumpers or wagons.

(3) The shallow trenches referred to are excavations such as those taken out for house foundations, kerb and channel foundations, etc.

(4) The rock referred to is rock with many fissures.

Description *Excavate and load only.* *(See notes above.)*	*Nature of ground and labour hours excavating and loading only, per cu. yd.*						
	Firm sand	*Loamy soil, soft or sandy clay, or marl*	*Stiff clay*	*Gravel and compact soil requiring picking*	*Chalk*	*Soft stratified fissured rock*	*Hard stratified fissured rock*
Excavate over areas and load to barrows ..	1·00	1·20	1·40	1·90	3·10	4·00	6·40
Excavate over areas and load to vehicles ..	1·20	1·40	1·60	2·10	3·30	4·20	6·60
Bulk excavation and load to barrows ..	0·80	1·00	1·20	1·60	2·60	3·30	5·30
Bulk excavation and load to vehicles ..	1·00	1·20	1·40	1·80	2·80	3·50	5·50
Excavate shallow trenches and load to barrows	1·60	2·00	2·30	3·00	4·70	6·00	9·20
Excavate shallow trenches and load to vehicles	1·80	2·20	2·50	3·20	4·90	6·20	9·40
Excavate small pier-holes and load to barrows	2·00	2·20	3·00	3·60	5·60	6·60	10·10
Excavate small pier-holes and load to vehicles	2·20	2·40	3·20	3·80	5·80	6·80	10·20
Excavation in underpinning and load to barrows	1·80	2·00	2·20	3·20	5·80	6·80	11·60
Excavation in underpinning and load to vehicles	2·00	2·20	2·40	3·40	6·00	7·00	11·80
Spread and level in 12 in. layers	0·30	0·40	0·60	0·35	0·40	0·40	0·40
Fill and ram in layers to form banks ..	0·50	0·60	0·70	0·55	0·60	0·60	0·60

Example No. 2.—Calculate the cost per cu. yd. of bulk excavation in loamy soil loaded into 2 cu. yd. dumpers, three men being employed digging and loading the dumpers, the excavated material being transported and tipped in a shoot 220 lin. yds. distant, the hire rate or working cost of the dumper, inclusive of driver, fuel and oil, being 8/- per hour and the labour rate 2/- per hour.

From the tables shown above and on pp. 154 *and* 157 the following is derived:

Labour hours excavating and loading loamy soil into dumpers per cu. yd. = 1·20 hrs.
Cu. yds. of loamy soil hauled in a 2 cu. yd. dumper per load .. .. = 1·70 cu. yds.
Time taken by a dumper to transport one load to tip 220 yds. distant .. = 0·13 hr.

$$\text{Time taken to load dumper (3 No. men excavating)} = \frac{1{\cdot}20 \times 1{\cdot}70}{3 \text{ No. men}} = 0{\cdot}68 \text{ hr.}$$

Time of haul = 0·13 hr.

$$\text{Number of dumpers required} = \frac{(\text{Time to load}) + (\text{Time of haul})}{\text{Time to load}}$$

$$= \frac{0{\cdot}68 + 0{\cdot}13}{0{\cdot}68} = 1{\cdot}20 \text{ No. dumpers.}$$

In the case of this example it will be noted that the time taken to load the vehicle is greatly in excess of the time of haul, and for this reason it would be uneconomical to use more than one dumper. The "build up" of the cost of the excavation is therefore based on the dumper hours per load, thus:

Cost per load of 1·70 *cu. yds.*

Dumper:
Standing while being loaded = 0·68 hr.
Time of haul = 0·13 hr.
Total dumper hours per 1·70 cu. yds. = 0·81 hr. at 8/- per hr. = 77·76 pence.
Labour:
3 No. men, 0·81 hr. = 2·43 hrs. at 2/- per hr. = 58·32 pence.
∴ Cost of 1·70 cu. yds. = 136·08 pence.
∴ Estimated cost per cu. yd. = $\frac{136\cdot08}{1\cdot70}$ = 80·30 pence per cu. yd.

BREAKING OUT BRICKWORK, CONCRETE, ROCK AND HARD ROAD SURFACES BY HAND AND BY COMPRESSORS AND PNEUMATIC TOOLS

Note.—(1) The hours shown are for breaking out only. They do *not* allow for loading the material into vehicles or transporting them.
(2) For loading materials, see pp. 155 and 156.
(3) For wheeling in barrows, see p. 157.
(4) For transporting in lorries, dumpers, etc., see p. 157.
(5) If the concrete is reinforced use a multiplier of 1·40 with the plant and labour hours shown.
(6) For breaking out asphalt or tarmacadam superimposed on concrete, treat the combined thickness as concrete.
(7) For scarifying roads with a roller fitted with scarifier, see p. 258.

Description *Break out only, not loaded or transported.* (*See notes above.*)	*Unit*	*Break out, using compressors and pneumatic tools*				*Break out by hand using points and sledges Labour hours*
		2 tool compressor		*3 tool compressor*		
		Compressor hours	*Labour hours*	*Compressor hours*	*Labour hours*	
Remove existing sett paving	Sq. yd.	0·08	0·16	0·053	0·16	1·00
Remove existing wood-block paving ..	Sq. yd.	0·03	0·06	0·02	0·06	0·40
Break out brickwork in lime mortar ..	Cu. yd.	0·18	0·36	0·12	0·36	2·50
Break out brickwork in cement mortar ..	Cu. yd.	0·24	0·48	0·16	0·48	3·75
Break out chalk—hard	Cu. yd.	0·33	0·66	0·22	0·66	5·00
Break out concrete in areas:						
4 in. thick	Sq. yd.	0·09	0·18	0·06	0·18	0·90
6 in. thick	Sq. yd.	0·12	0·24	0·08	0·24	1·60
9 in. thick	Sq. yd.	0·21	0·42	0·14	0·42	3·00
12 in. thick	Sq. yd.	0·33	0·66	0·22	0·66	4·60
Break out mass concrete	Cu. yd.	2·00	4·00	1·33	4·00	32·00
Break out sandstone	Cu. yd.	1·40	2·80	0·93	2·80	20 00
Break out water-bound roads on hardcore:						
6 in. thick	Sq. yd.	0·08	0·16	0·053	0·16	1·10
9 in. thick	Sq. yd.	0·10	0·20	0·068	0·20	1·40
12 in. thick	Sq. yd.	0·13	0·26	0·087	0·26	1·70
Break out tarmacadam roads on hardcore:						
6 in. thick	Sq. yd.	0·09	0·18	0·06	0·18	1·20
9 in. thick	Sq. yd.	0·12	0·24	0·08	0·24	1·50
12 in. thick	Sq. yd.	0·15	0·30	0·10	0·30	1·80
Break out asphalt roads on hardcore:						
6 in. thick	Sq. yd.	0·11	0·22	0·073	0·22	1·30
9 in. thick	Sq. yd.	0·15	0·30	0·10	0·30	1·60
12 in. thick	Sq. yd.	0·19	0·38	0·127	0·38	2·00
Break out tarmacadam paths on clinker or hardcore:						
3 in. thick	Sq. yd.	0·03	0·06	0·02	0·06	0·60
4 in. thick	Sq. yd.	0·04	0·08	0·027	0·08	0·70
Remove existing 2 in. artificial stone paving	Sq. yd.	—	—	—	—	0·40
Demolish brick-built property per 100 cu. ft. of building	Per 100 Cu. ft.	—	—	—	—	5·00

Note.—For loading loose materials to vehicles by hand, see p. 155.

Excavation by Mechanical Excavators fitted with Shovel, Skimmer, Dragline or Grab Equipment

In estimating the cost of excavation carried out by the above type of mechanical excavating plant, five items have to be noted in order that the cost may be calculated, viz.:

1. The time taken by the plant to dig and load 1 cu. yd. of solid material into the vehicle used to transport it.
2. The time the vehicle stands while it is loaded and the cubic yards hauled per load.
3. The time the vehicle takes to travel to the tip, off-load and return for the next load.
4. The cost of any attendant labour along with the plant, on the tip, trimming, etc.
5. The cost incurred in hauling the plant, unless this is otherwise allowed for.

In connection with transport by lorries, where the weight of load factor has to be considered, the cu. yds. of material hauled per load are variable, since the weight of various grounds per cu. yd. are variable. In the table showing the cu. yds. of various grounds hauled in lorries per load, this factor is allowed for, as is the bulkage of the respective materials, normal "heaping" of the loads being allowed for.

In order that the estimator may have available data from which to estimate the cost of excavation, using this type of plant for all combinations of excavating and transporting plant and for various classes of ground hauled to various lengths of haul, the following tables are shown:

1. Table showing the time taken by the excavating plant to dig and load 1 cu. yd. of solid material into the vehicle used for transporting it.
2. Table showing the cu. yds. of solid excavation hauled per load, using various types and sizes of haulage plant.
3. The average time taken by the vehicles to haul *the load* to tip, off-load and return for the next load.

In order to illustrate the method of using these tables two examples are shown, one where the haulage is carried out by 5 ton lorries fitted with mechanical tipping gear, and the other where the haulage of the excavated material is carried out by locomotive and wagons running on 2 ft. gauge Decauville track.

Example No. 1.—Calculate the cost of excavating sandy clay with a ½ cu. yd. excavator fitted with skimmer scoop equipment, the excavated material being hauled in 5 ton tipping lorries fitted with mechanical tipping gear to a shoot a quarter of a mile away. A banksman is in attendance on the excavator while two men are employed on trimming the formation and one man on the tip, i.e. a total of four men in all.

For purposes of this example the following rates are assumed:

Hire rate or working cost per hour of the ½ cu. yd. mechanical excavator, inclusive of driver, fuel and oil	12/6 per hr.
Hire rate or working cost per hour of 5-ton lorries, inclusive of driver, fuel and oil	8/- ,,
Labour rate	2/- ,,

From the table shown on p. 152

Hours taken by ½ cu. yd. mechanical excavator with skimmer scoop attachment to dig and load 1 cu. yd. of sandy clay = 0·053 hrs. per cu. yd.

From the table shown on p. 154

The cu. yds. of solid sandy clay hauled per load in a 5 ton lorry is 3·75 cu. yds. per load.

From the table shown on p. 157

The time taken by the lorry to haul one load to tip quarter of a mile distant, off-load and return for the next load = 0·14 hrs. per load.

Time taken to load lorry = 0·053 × 3·75 = 0·20 hr.
Time of haul = 0·14 hr.

$$\text{Number of lorries required} = \frac{(\text{Time to load}) + (\text{Time of haul})}{\text{Time to load}}$$

$$= \frac{0{\cdot}20 + 0{\cdot}14}{0{\cdot}20} = 1{\cdot}70 \text{ No. lorries.}$$

∴ Actual number of lorries used = 2 No.

The cost of the excavation per cubic yard is therefore "built up" as follows:

Plant and Labour Cost per hour:

Mechanical excavator = 1 hr. at 12/6 per hr. = 12/6
2 No. lorries = 2 hrs. at 8/- per hr. = 16/-
4 No. labourers = 4 hrs. at 2/- per hr. = 8/-
∴ Plant and labour cost per hr. = 36/6

Output of mechanical excavator = 0·053 hr. per cu. yd.
∴ Estimated cost per cu. yd. = 0·053 × 36/6 = 23·22 pence per cu. yd.

Note.—(1) The estimator, knowing the nature of the excavation to be carried out and the conditions at the tip, must assess what labour is required and allow accordingly.
(2) The haulage cost of the plant is not allowed for. This may be allowed for by assessing the haulage cost of the plant or getting a firm quotation for it and dividing this cost by the total cu. yds. of excavation which have to be carried out. The resultant figure may then be added to the excavation cu. yd. Alternatively, the plant haulage may be allowed for on a "lump sum" basis.

Example No. 2.—Calculate the cost of excavating sandy clay with a ½ cu. yd. mechanical excavator fitted with skimmer scoop equipment, the excavated material being transported to a shoot a quarter of a mile away by locomotive and Decauville wagons on 2 ft. gauge track. One banksman is in attendance on the excavator, and it is assessed that the following labour will be required: one man in attendance on the locomotive on points, etc.; two men on track maintenance; two men at the tip slewing track, levelling, etc.

For purposes of this example the following rates are assumed:

Hire rate or working cost per hour of mechanical excavator, including driver, fuel and oil .. .. = 12/6 per hr.
Hire rate or working cost per hour of locomotive, track and wagons, including driver, fuel and oil .. .. = 10/- „
Labour rate .. .. = 2/- „

The Number of Wagons required per set and the cu. yds. of Solid Excavation hauled "per set of Wagons"

By correctly assessing the number of wagons required per set in conjunction with the output of the excavating plant and length of haul, one set of wagons is being loaded while another is being hauled.

Referring to the table shown on p. 157 it will be seen that the average time taken by the locomotive to haul to tip a quarter of a mile away is 0·28 hours per trip.

Referring to the table shown on p. 152 it will be seen that a ½ cu. yd. mechanical excavator fitted with a skimmer scoop attachment digs and loads 1 cu. yd. of sandy clay in 0·053 hour.

$$\therefore \text{ In } 0{\cdot}28 \text{ hrs. it will dig and load } \frac{0{\cdot}28}{0{\cdot}053} = 5{\cdot}28 \text{ cu. yds. of solid excavation.}$$

Referring to the table showing the bulkage of excavated materials of various kind on p. 60, it will be noted that the bulkage of sandy clay is 1·40.

∴ Sufficient wagons per set must be used to haul 5·28 cu. yds. × 1·40 = 7·39 cu. yds. of sandy clay per trip.

The Cost of Excavating and Loading the Wagons only, per cu. yd.

From the table shown below, the excavation and loading cost is given by:

Mechanical excavator 0·053 hrs. at 12/6 per hr. = 7·95 pence per cu. yd.

The Transporting Cost per cu. yd.

The locomotive time taken per trip is 0·28 hrs., and the load of solid excavation hauled is 5·28 cu. yds.

$$\therefore \text{The haulage time per cu. yd.} = \frac{0{\cdot}28\ \text{hr.}}{5{\cdot}28\ \text{cu. yds.}} = 0{\cdot}053\ \text{hrs.}$$

Note.—This 0·053 hrs. is the same as the excavating and loading hours taken by the mechanical excavating plant.

∴ The transporting cost per cu. yd. = 0·053 hrs. at 10/- per hr. = 6·36 pence per cu. yd.

The Labour Cost per cu. yd.

The total labour including the banksman, men on track and at the tip is 5 No. men, while the mechanical excavator excavates 1 cu. yd. every 0·053 hours.

∴ The total labour hours per cu. yd. = 5 × 0·053 = 0·265 hours.

∴ The labour cost per cu. yd. = 0·265 hrs. at 2/- per hr. = 6·26 pence per cu. yd.

The total cost of excavating, loading and transporting the material, therefore, is:

Excavate and load	7·95	pence per cu. yd.
Transport	6·36	,, ,, ,,
Attendant labour	6·26	,, ,, ,,
Total cost	20·57	,, ,, ,,

Note.—(1) The haulage cost of the plant is not allowed for. This may be done by assessing the haulage cost or getting a firm quotation for it, when it may be allowed for on a "lump sum" basis or in the unit cost of the excavation itself, this being done by dividing the haulage cost by the total cu. yds. of excavation to be carried out, the resultant figure being then added to the excavation cost shown.

(2) The cost of laying and removing the track must also be allowed for. The estimator is referred to Section Twenty-two, "Platelayer", where data are shown from which this may be estimated.

(3) The estimator must himself assess the number of men required on track maintenance and on the tip, knowing the nature of the site and the work to be carried out.

EXCAVATION BY MECHANICAL EXCAVATORS FITTED WITH SKIMMER SCOOP EQUIPMENT

Note.—(1) The hours shown are those taken by the plant to dig and load 1 cu. yd. They also represent the hours the transporting plant stands while 1 cu. yd. of material is loaded into it.

(2) For the cu. yds. of material hauled per load, employing transporting plant of various types and capacities, see p. 154.

(3) For the time taken by various types of transporting plant to haul to shoot at various lengths of haul, see p. 157.

Bucket capacity of in cu. yds.	*Nature of ground and plant hours excavating and loading per cu. yd.* Note.—*The hours shown also represent the hours the transporting plant stands while 1 cu. yd. of material is loaded into it.*						
	Firm sand	*Loose excavated material*	*Loamy soil, soft or sandy clay or marl*	*Gravel*	*Broken stone or metal*	*Stiff clay*	*Soft chalk*
¼	0·083	0·101	0·120	0·130	0·133	0·141	0·166
⅜	0·050	0·063	0·070	0·075	0·080	0·085	0·100
½	0·037	0·047	0·053	0·056	0·060	0·063	0·074
⅝	0·025	0·032	0·035	0·038	0·040	0·043	0·050
¾	0·022	0·028	0·030	0·033	0·035	0·038	0·044
⅞	0·019	0·024	0·027	0·029	0·031	0·033	0·038
1	0·017	0·022	0·024	0·026	0·028	0·030	0·034

EXCAVATION BY MECHANICAL EXCAVATORS FITTED WITH DRAGLINE OR SHOVEL EQUIPMENT

Note.—(1) The hours shown are those taken by the plant to dig and load 1 cu. yd. They also represent the hours the transporting plant stands while 1 cu. yd. is loaded into it.

(2) For the cu. yds. of material hauled per load, employing transporting plant of various types and capacities, see p. 154.

(3) For the time taken by various types of transporting plant to haul to shoot at various lengths of haul, see p. 157.

Bucket capacity of machine in cu. yds.	*Nature of ground and plant hours excavating and loading per cu. yd.* Note.—*The hours shown also represent the hours the transporting plant stands while 1 cu. yd. is loaded into it.*						
	Firm sand	*Loose excavated material*	*Loamy soil, soft or sandy clay, or marl*	*Gravel*	*Broken stone or metal*	*Stiff clay*	*Soft chalk*
¼	0·063	0·079	0·088	0·095	0·101	0·107	0·126
⅜	0·039	0·049	0·055	0·059	0·063	0·066	0·078
½	0·028	0·035	0·039	0·042	0·045	0·048	0·056
⅝	0·019	0·024	0·027	0·029	0·031	0·032	0·038
¾	0·016	0·020	0·023	0·024	0·026	0·027	0·032
⅞	0·014	0·018	0·020	0·021	0·023	0·024	0·028
1	0·012	0·015	0·017	0·018	0·020	0·021	0·024

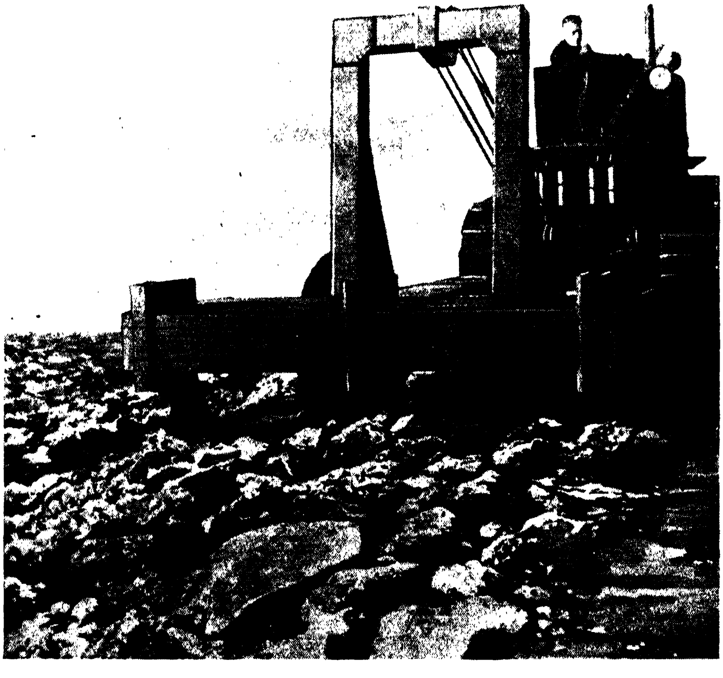

FIG. 18.—

HEAVY DUTY RIPPER

This heavy duty ripper is used ahead of scraper to save wear and strain on equipment

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EXCAVATION BY MECHANICAL EXCAVATORS FITTED WITH GRABS

Note.—Grabs are only suitable for excavating soft grounds, such as gravel, sand, etc.; with hard grounds they are uneconomical. They are chiefly used for loading materials such as ballast, gravel, shingle, broken stone, road metal, sand, etc.

Size of grab in cu. yds.	*Nature of ground and plant hours per cu. yd.*			
	Excavating and loading		*Loading only loose materials*	
	Sand	*Loam and gravel*	*Sand*	*Gravel, shingle and broken stone 2½ in. down*
¼	0·133	0·300	0·100	0·111
⅜	0·089	0·200	0·066	0·075
½	0·066	0·150	0·050	0·055
⅝	0·054	0·120	0·040	0·044
¾	0·044	0·100	0·033	0·037

Note.—For loading loose materials to vehicles mechanically and from storage hoppers, see p. 156.

THE CUBIC YARDS OF EXCAVATED MATERIAL HAULED PER LOAD BY VARIOUS TYPES OF TRANSPORTING PLANT

Note.—(1) In hauling excavated material by horse and cart the weight of load hauled is taken as being 1 ton.

(2) In hauling excavated material by lorry the weight of the load hauled should not exceed that which the lorry is designed to carry. The table shows the cu. yds. of solid material hauled per load, taking bulkage, normal heaping of the load and the weight factor into account.

(3) Vehicles such as dumpers and wagons drawn by tractors or locomotives are rated on a volume basis, their "Struck measured capacity" in cu. yds. being stated, thus the "struck measured capacity" of a 2 cu. yd. dumper is 2 cu. yds. The vehicles have a "heaped capacity", the load being "heaped" in the vehicles, and this heaping of the load in conjunction with the bulkage of the material must be taken into account in assessing the cu. yds. of solid material hauled per load.

In the table is shown the cu. yds. of solid excavated material hauled per cu. yd. of "struck measured capacity", this allowing for heaping the load and the bulkage of the material. Thus if sandy clay is hauled in a dumper whose "struck measured capacity" is 2 cu. yds., the cu. yds. of solid material hauled per load is 2 × 0·85 cu. yd. = 1·70 cu. yds.

Nature of material hauled	*Weight of the material in the solid. Cu. yds. per ton*	*Haulage by horse and cart and lorries. The cu. yds. of solid material hauled per load*							*The cu. yds. of solid material hauled by dumpers or in wagons per cu. yd. of "struck measured capacity"*
		Horse Horse and cart	1 *ton lorry*	2 *ton lorry*	3 *ton lorry*	4 *ton lorry*	5 *ton lorry*	6 *ton lorry*	
Chalk	0·58	0·58	0·58	1·16	1·74	2·32	2·90	3·48	0·70
Loamy soil and soft or sandy clay	0·75	0·75	0·75	1·50	2·25	3·00	3·75	4·50	0·85
Stiff clay	0·69	0·69	0·69	1·38	2·07	2·76	3·45	4·14	0·80
Gravel	0·75	0·75	0·75	1·50	2·25	3·00	3·75	4·50	1·14
Loam	0·87	0·87	0·87	1·74	2·61	3·48	4·35	5·22	0·92
Marl	0·75	0·75	0·75	1·50	2·25	3·00	3·75	4·50	0·98
Sand	0·87	0·87	0·87	1·74	2·61	3·48	4·35	5·22	1·09
Soil	0·83	0·83	0·83	1·66	2·49	3·32	4·15	4·98	0·90
Broken rock or metal	0·55	0·55	0·55	1·10	1·65	2·20	2·75	3·30	0·66

LOADING LOOSE MATERIALS BY HAND

Note.—(1) The hours shown are for loading only and do not allow for wheeling or transporting, for which see p. 157.

(2) The vehicles referred to are vehicles such as lorries, dumpers, etc.

(3) The materials referred to are loose—no excavation is involved.

Nature of material	*Labour hours loading into vehicles*	
	Per ton	*Per cu. yd.*
Ashes	0·70	0·46
Asphalt	1·00	1·57
Bricks, loose tipped	0·60	0·61
Bricks, stacked	·20	1·60
Broken concrete	0·80	0·75
Chalk	0·65	0·65
Clay, loamy	0·75	0·72
Clay, stiff	0·80	0·78
Clinker	0·70	0·38
Concrete, mixed	0·70	1·12
Coke	0·70	0·35
Girders, R.S. joists, etc.	1·00	—
Gravel	0·65	0·76
Gully grates and frames	1·00	—
Hardcore, brick	0·82	0·80
Hardcore, concrete	0·80	0·78
Kerb	0·90	—
Manhole covers	1·00	—
Marl	0·75	0·98
Paving slabs	1·10	—
Pipes, asbestos cement	1·20	—
Pipes, cast iron	1·00	—
Pipes, concrete	1·10	—
Pipes, stoneware	1·10	—
Pipes, steel	1·10	—
Precast concrete units	1·10	—
Rails	1·00	—
Road metal	0·60	0·58
Sand	0·60	0·68
Sett paving, granite	0·75	—
Shale	0·70	0·72
Shingle	0·70	0·80
Soil	0·70	0·68
Steel reinforcement	1·20	—
Stone broken, ½ in. down	0·60	0·65
Stone broken, ½ to 2½ in.	0·65	0·75
Stone broken, 2½ to 4 in.	0·70	0·85
Stone broken, 4 to 6 in.	0·75	0·95
Stone broken, 6 to 9 in.	0·80	1·00
Tarmacadam	1·10	0·90
Timber, carcassing—soft wood	1·20	0·48
Trench timber	1·15	0·45
Wood-block paving, 4 in. deep	*Per sq. yd.* 0·10	—

LOADING LOOSE MATERIALS TO VEHICLES MECHANICALLY AND DIRECT FROM STORAGE HOPPERS

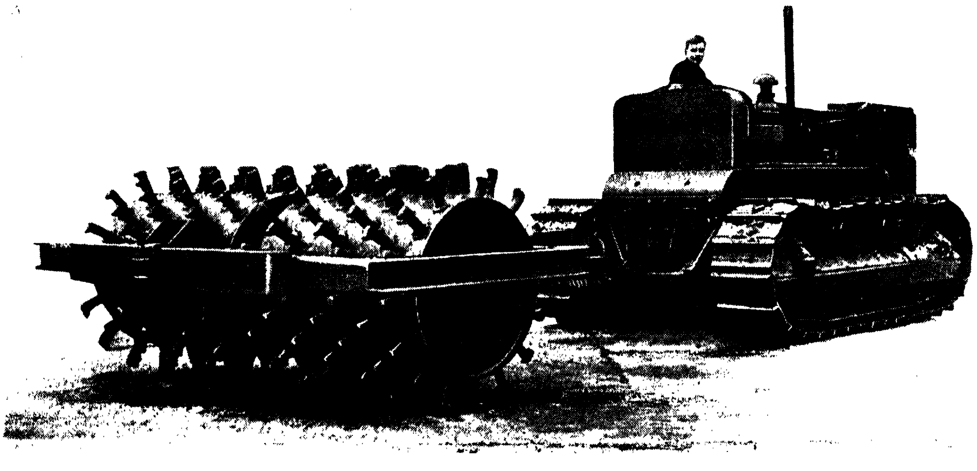
Note.—(1) The hours shown are those taken by the plant to load 1 cu. yd. They also represent the hours the transporting plant stands while 1 cu. yd. is loaded into it.

(2) For the time taken by various types of transporting plant to haul to shoot at various lengths of haul, see p. 157.

(3) Knowing the weight of the materials in tons per cu. yd., the plant hours loading per ton may calculated.

(4) For weights of various materials in the loose, see pp. 131 and 267.

Type of plant used to load	*Size of bucket in cu. yds.*	*Nature of material loaded and plant hours loading per cu. yd.*			
		Ashes, clinker, coke, media, sand	*Concrete aggregates, chips, gravel, road metal and shingle*	*Brick, concrete and stone hard-core*	*Asphalt and tarmacadam*
Mechanical dragline or shovel	¼	0·095	0·100	0·115	0·110
Mechanical dragline or shovel	⅜	0·055	0·058	0·068	0·064
Mechanical dragline or shovel	½	0·040	0·042	0·049	0·046
Mechanical skimmer . .	¼	0·120	0·126	0·147	0·140
Mechanical skimmer . .	⅜	0·071	0·075	0·087	0·083
Mechanical skimmer . .	½	0·053	0·056	0·065	0·062
Mechanical grab	¼	0·237	0·250	0·290	0·280
Mechanical grab	⅜	0·160	0·167	0·195	0·186
Mechanical grab	½	0·112	0·118	0·126	0·120
Direct loading from elevated storage hoppers	—	0·030	0·035	—	0·040
High lift loading shovel . .	¼	0·079	0·083	0·095	0·090
High lift loading shovel . .	⅜	0·052	0·055	0·057	0·060
High lift loading shovel . .	½	0·040	0·042	0·044	0·046



Blaw-Knox Ltd.

FIG. 19.—SHEEPSFOOT TAMPING ROLLER

This roller reaches places on the field inaccessible to ordinary rollers

WHEELING IN 3 CU. FT. HANDBARROWS TO A 25 YD. RUN

Note.—The hours shown refer to barrow runs up to 25 lin. yds.

Nature of ground	*Labour hours wheeling and tipping per cu. yd.*
Chalk	0·76
Loamy soil, soft or sandy clay	0·64
Stiff clay	0·68
Gravel	0·52
Marl	0·61
Sand	0·50
Soil	0·59
Hardcore, broken rock or concrete ..	0·80
Metalling, scarifyings, etc.	0·60

THE TRAVELLING TIME TAKEN PER LOAD TO HAUL TO TIP, OFF-LOAD AND RETURN FOR THE NEXT LOAD, USING VARIOUS TYPES OF TRANSPORTING PLANT

Note.—(1) The hours shown are the average hours taken per round trip, including the time taken to off-load. They do *not* allow for the time the vehicle stands while it is being loaded.

(2) The hours shown for haulage by lorries are based on lorries fitted with mechanical tipping gear, and assume that the vehicles run on roads or reasonably level firm surfaces.

(3) The hours shown for haulage by tractor-drawn wagons or by locomotive and wagons are the hours taken "per set of wagons", allowing for the off-loading time, it being assumed that sufficient labour is available to off-load without undue loss of time. In the case of locomotive and wagons, shunting time is also allowed for in the hours shown.

(4) For the cu. yds. of material of various kinds hauled per load, see table on p. 154.

Length of haul from site where loaded to point of off-loading in yds. and miles	*Type of haulage plant used and plant hours per load*						
	Horses and carts	*Lorries fitted with mechanical tipping gear*	*Dumpers*	*Caterpillar tractor-drawn wagons*	*Wheeled tractor-drawn wagons*	*Locomotive and wagons on 2 ft. gauge decauville track*	*Locomotive and wagons on 4 ft. 8½ in. gauge track*
100 yds.	0·12	0·09	0·10	0·16	0·10	0·16	0·19
200 yds.	0·15	0·10	0·12	0·20	0·11	0·20	0·23
220 yds.	0·16	0·11	0·13	0·22	0·12	0·22	0·25
300 yds.	0·17	0·12	0·14	0·24	0·13	0·24	0·28
400 yds.	0·22	0·13	0·18	0·27	0·14	0·27	0·30
440 yds.	0·25	0·14	0·19	0·28	0·16	0·28	0·32
500 yds.	0·28	0·15	0·20	0·30	0·17	0·30	0·34
660 yds.	0·34	0·16	0·23	—	0·18	0·35	0·40
880 yds.	0·43	0·18	0·26	—	0·21	0·40	0·46
1 mile	0·75	0·27	0·40	—	0·31	0·62	0·68
2 miles	1·50	0·41	—	—	0·47	0·94	1·10
3 miles	—	0·54	—	—	—	—	—
4 miles	—	0·67	—	—	—	—	—
5 miles	—	0·79	—	—	—	—	—
6 miles	—	0·90	—	—	—	—	—
7 miles	—	1·00	—	—	—	—	—
8 miles	—	1·10	—	—	—	—	—
9 miles	—	1·20	—	—	—	—	—
10 miles	—	1·30	—	—	—	—	—

Excavation by Tractors and Scrapers, using Tractors of the Caterpillar Track Type

Excavation by tractors and scrapers on work which is suited to this type of plant is a very cheap form of excavation, and these machines are capable of large outputs per hour on lengths of haul for which they are suited.

In carrying out excavation with this type of plant the following conditions must be fulfilled:

1. The nature of the work to be carried out must be such that it is suitable for this type of plant.
2. The nature of the ground to be excavated should be suited to this type of plant.
3. The length of haul to tip should not be excessive.

The plant consists of two units, viz.:

(*a*) The tractor.
(*b*) The scraper.

The scraper is in itself the container in which the excavated material is hauled. As it is hauled by the tractor it excavates the ground with a knife-cutting edge, the excavated material passing into the body of the scraper. When full, the cutting edge is raised and the tractor hauls the load to tip, where it is off-loaded.

This type of plant is eminently suited for surface excavation in connection with aerodrome runways, large road contracts, site levelling, etc., where the excavated material is "cut and filled" or disposed of on a length of haul not in excess of 500 yds. The output in cu. yds. per hour falls steadily as the length of haul increases, being at the 500 yd. haul only approximately 50% of the output at 100 yds. In the case of hauls in excess of this length, excavation with this type of plant is therefore not economical, and in such cases mechanical excavating plant in conjunction with vehicular transport should be used.

Tractors and scrapers are capable of excavating all normal ground such as soil, loamy soil, loamy clay, clay, gravel, etc. With hard grounds such as chalk, soft rock etc., the ground is generally broken up and loosened by a tractor-drawn ripper or rooter prior to its being excavated by the scraper unit.

The ripper consists of a unit with pronged teeth, these being weighted down. This unit is drawn by the tractor, the teeth breaking up the hard ground and loosening it so that it is capable of being readily excavated by the tractor and scraper, this excavation being carried out as a subsequent operation. This ripping of hard surfaces prior to using a scraper greatly reduces "tear and wear" on the scraping unit.

Tractors of various makes and horse power are available, these in turn being capable of handling scrapers of various capacities. The table on the opposite page shows the comparative types of different makes of tractors together with the maximum size of scraper to use with them.

In using this type of plant, labour in attendance is not usually necessary but, on occasions, one man may be required. The estimator must judge whether attendant labour is necessary or not, this depending on the nature of the work and the prevailing site conditions.

For purposes of estimating the cost of excavation using this type of plant, data are shown for excavating and hauling easily dug sand with tractors and scrapers of all sizes, the data covering lengths of haul up to 500 lin. yds. For classes of ground, other than easily dug sand a table of multipliers is shown for use with the data shown in the main table.

In order to illustrate the method of estimating the cost of excavation by tractor and scraper a typical example is shown.

Example.—Calculate the cost of excavating soft clay, using a caterpillar D6 tractor with a Le Tourneau Model M scraper, the excavated material being hauled an average length of haul of 400 yds.

For purposes of this example it will be assumed that the hire rate or working cost per hour of the tractor and scraper including driver, fuel and oil is 30/- per hour and also that one man is in attendance on the plant.

Referring to the table shown on p. 160

The hours taken by a D6 tractor and scraper to excavate and haul easily dug sand to an average length of haul of 400 lin. yds. = 0·04 hrs. per cu. yd.

Referring to the table of multipliers it will be seen that the plant-hour multiplier for soft clay is 1·33.

∴ Plant hours excavating and hauling soft clay = 1·33 × 0·04 hrs. per cu. yd. = 0·053 hrs.

∴ Cost per cu. yd. of excavating and hauling soft clay is:

Tractor and scraper, 0·053 hrs. at 30/- per hr. = 19·08 pence per cu. yd.
Labour .. .. 0·053 hrs. at 2/- per hr. = 1·27 " " "
∴ Total cost .. .. = 20·35 " " "

Note.—The haulage cost of the plant is not allowed for. This may be allowed for by assessing the haulage cost or getting a firm quotation for it and dividing this cost by the total cu. yds. of excavation to be carried out. The resultant figure may then be added to the excavation cost per cu. yd. The plant haulage cost may also be allowed for on a "lump sum" basis if desired.

EXCAVATION BY TRACTORS AND SCRAPERS

TABLE SHOWING COMPARATIVE TYPES OF TRACTORS OF DIFFERENT MAKES

Caterpillar	*International*	*Allis Chalmers*	*Maximum size of scraper to use. Cu. yds.*
D2	T.D.6	–	—
D4	T.D.9	—	4
D6	T.D.14	H.D.7	6
D7	T.D.18	H.D.10	8
D8	—	H.D.14	12

CHIEF CHARACTERISTICS OF CATERPILLAR TYPE TRACTORS

Description	*Caterpillar tractor type No.*				
	D2	D4	D6	D7	D8
Drawbar horse power	25	35	55	80	113
Approximate gallons of fuel (diesel oil) used per hour	1·00	1·70	2·00	2·90	4·00
Maximum size of scraper to use, cu. yds.	—	4	6	8	12
Speed forward, low gear, m.p.h. ..	1·70	1·70	1·40	1·40	1·60
Speed forward, top gear, m.p.h. ..	5·10	5·40	5·80	6·00	4·90
Speed in reverse, low gear, m.p.h. ..	2·10	1·90	1·80	1·60	1·60
Speed in reverse, top gear, m.p.h. ..	2·10	1·90	5·50	5·40	2·60
Weight of machine, tons	3·10	4·63	7·54	10·67	15·38

EXCAVATION BY TRACTORS AND SCRAPERS

Note.—(1) The hours shown are for excavating firm sand. For other classes of ground use the table of multipliers shown.
(2) For table showing the comparable types of tractors, see previous page.

Type of tractor and scraper	*Rated capacity*		*Length of haul (one way) in lin. yds. and plant hours per cu. yd.*				
	Heaped cu. yds.	*Struck cu. yds.*	100 *yds.*	200 *yds.*	300 *yds.*	400 *yds.*	500 *yds.*
D4, Le Tourneau, Model X ..	4·0	3·5	0·031	0·038	0·053	0·060	0·066
D6, Le Tourneau, Model M ..	7·5	6·0	0·019	0·026	0·034	0·040	0·045
D7, Le Tourneau, Model L ..	9·5	7·2	0·016	0·022	0·028	0·032	0·037
D7, Le Tourneau, Model LS ..	11·0	8·2	0·014	0·019	0·025	0·028	0·030
D8, Le Tourneau, Model K ..	14·0	11·0	0·012	0·015	0·019	0·022	0·026
D8, Le Tourneau, Model LP ..	15·0	12·1	0·011	0·014	0·018	0·021	0·024
D8, Le Tourneau, Model F ..	16·0	12·5	0·010	0·013	0·017	0·019	0·021

TABLE OF MULTIPLIERS FOR USE WITH THE TABLE SHOWN FOR EXCAVATION BY TRACTORS AND SCRAPERS FOR GROUND OTHER THAN FIRM SAND

Nature of ground	*Plant hour multiplier*
Firm sand	1·00
Firm soil	1·25
Gravel	1·25
Loamy soil, soft or sandy clay and marl ..	1·33
Stiff clay	1·50
Soft chalk	3·00
Soft friable rock	4·00

Earth Moving by Angledozers and Bulldozers

Angledozers and bulldozers consist of a tractor to which is fitted a blade, this blade pushing the ground as the tractor forces its way ahead. In the case of the angledozer, this blade can be set at an angle to the direction of motion or at an angle, while in the case of the bulldozer, it is set at right angles to the direction of motion of the tractor.

The machines are available in various sizes and horse-powers.

Angledozers are suitable for cutting track out of sloping ground, such as hill-sides, and are also used for trench filling or moving earth bodily in a line parallel to the direction taken by the machine.

Bulldozers may be used for digging ramps or short cuttings and also pushing ground or materials. The maximum length of push should not exceed 100 lin. yds., as they are uneconomical where the distance to be pushed is in excess of this.

In the case of both machines the output is greater when working downhill than on the level or uphill.

In the tables shown for estimating purposes, data are shown for various sizes of machines, carrying out the work "on the level" and on gradients of "1 in 7 up" and "1 in 7 down". The data shown are for moving sand.

For ground other than sand, a table of multipliers is shown.

EARTH MOVING BY ANGLEDOZERS

Note.—(1) The hours shown are for moving sand, Use the table of multipliers shown for other classes of ground.
(2) For table showing comparative types of tractors of different makes, see p. 159.
(3) The data shown are applicable also to refilling trenches by angledozer.

Type of tractor	*Gradient and plant hours per cu. yd.*		
	Level	*1 in 7 up*	*1 in 7 down*
D4	0·017	0·028	0·013
D6	0·013	0·021	0·010
D7	0·010	0·016	0·008
D8	0·008	0·013	0·006

TABLE OF MULTIPLIERS FOR USE WITH THE TABLE SHOWN FOR EARTH MOVING BY ANGLEDOZERS FOR DIFFERENT CLASSES OF GROUND

Nature of ground	*Plant hour multiplier*
Sand	1·00
Broken rock	2·50
Chalk	3·00
Gravel	1·25
Loamy soil, soft or sand, clay or marl	1·33
Stiff clay	2·70
Soil	1·25

EARTH MOVING BY BULLDOZERS

Note.—(1) The hours shown are for moving sand. Use the table of multipliers on p. 163 for other classes of ground.
(2) For table showing the comparable types of tractors of different makes, see p. 159.
(3) The data shown are also applicable to refilling excavations by bulldozer.

Type of tractor	*Length of push in feet*	*Gradient and plant hours per cu. yd.*		
		Level	*1 in 7 up*	*1 in 7 down*
D4	20	0·012	—	—
D4	50	0·026	0·044	0·021
D4	100	0·040	0·065	0·030
D4	150	0·055	0·090	0·042
D4	200	0·075	—	—
D4	300	0·102	—	—
D6	20	0·009	—	—
D6	50	0·020	0·033	0·015
D6	100	0·030	0·050	0·023
D6	150	0·041	0·066	0·031
D6	200	0·057	—	—
D6	300	0·080	—	—
D7	20	0·007	—	—
D7	50	0·012	0·019	0·009
D7	100	0·017	0·029	0·013
D7	150	0·025	0·041	0·019
D7	200	0·033	—	—
D7	300	0·046	—	—
D8	20	0·005	—	—
D8	50	0·009	0·015	0·007
D8	100	0·013	0·022	0·100
D8	150	0·019	0·031	0·150
D8	200	0·026	—	—
D8	300	0·036	—	—

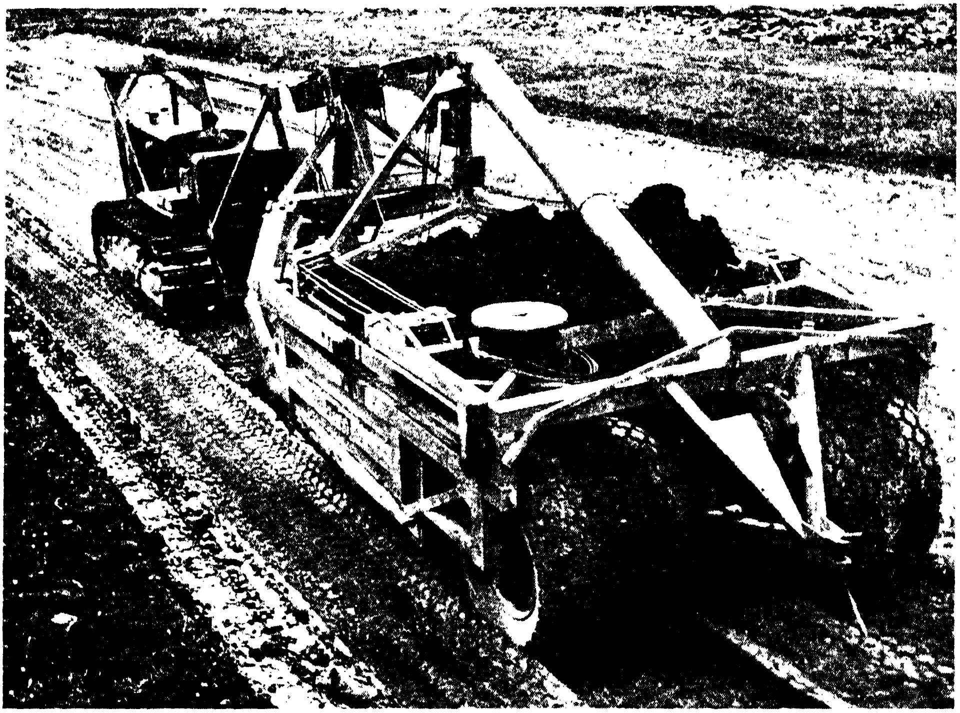


FIG. 20. CATERPILLAR TRACTOR AND SCRAPER *Jack Olding & Co. Ltd.*

FIG. 21.—CATERPILLAR AND BULLDOZER *Jack Olding & Co. Ltd.*

TABLE OF MULTIPLIERS FOR USE WITH THE TABLE SHOWN FOR EARTH MOVING BY BULLDOZERS FOR DIFFERENT CLASSES OF GROUND

Nature of ground	*Plant hour multiplier*
Sand	1·00
Broken rock	2·50
Chalk	3·00
Gravel	1·25
Loamy soil, soft or sandy clay or marl	1·33
Stiff clay	2·70
Soil	1·25

OPERATIONS IN CONNECTION WITH SOIL SURFACE TREATMENT AND SOIL STABILISATION

Description	*Plant used*	*Unit*	*Plant hours*	*Labour hours*
Consolidating grass, one way	2 ton petrol roller	Acre	0·50	—
Consolidating soil 6 in. thick, one way	Tractor-drawn rib roller	Acre	0·25	—
Consolidating soil 6 in. thick, one way	Tractor-drawn sheepsfoot roller	Acre	0·30	—
Consolidating soil 6 in. thick, one way	Tractor-drawn smooth roller	Acre	0·20	—
Consolidating hoggin 6 in. thick, one way	Tractor-drawn sheepsfoot roller	Acre	0·33	—
Cultivate once over	Tractor-drawn cultivator	Acre	0·40	—
Cut mole drains	Mole plough	Lin. yd.	0·003	0·003
Cut land drain trench	Trenching plough	Lin. yd.	0·006	0·006
Fertilizing, 8 cwt. per acre	Horse, driver and drill	Acre	1·20	—
Grass seeding, one way, 40 to 50 lb. seed per acre	Horse, driver and seeder	Acre	0·35	0·70
Grass seeding, two ways, 40 to 50 lb. seed per acre	Horse driver and seeder	Acre	0·60	1·20
Harrow once over	Tractor-drawn disc harrow	Acre	0·30	—
Harrow once over	Tractor-drawn spike or peg-tooth harrow	Acre	0·25	—
Harrow once over	Horse-drawn harrow	Acre	0·60	—
Liming, 2·00 tons per acre	Horse, driver and drill	Acre	2·20	—
Plough once over	Tractor-drawn disc plough	Acre	1·80	—
Plough once over	Tractor-drawn 4 furrow plough	Acre	1·25	—
Plough once over	Tractor-drawn 5 furrow plough	Acre	1·00	—
Plough once over	Two-horse drawn plough	Acre	10·00	—
Roll one way	Tractor-drawn ribbed roller	Acre	0·25	—
Roll one way	Tractor-drawn sheepsfoot roller	Acre	0·30	—
Roll one way	Tractor-drawn smooth roller	Acre	0·20	—
Roll one way	Horse-drawn roller	Acre	0·50	—
Rotary tilling	Tractor-drawn rotary tiller	Acre	0·60	—
Watering	Horse and water-cart and spraying bar	Acre	1·00	2·00
Weed spraying	Horse and water-cart and spraying bar	Acre	1·20	2·40

EXCAVATOR

SUNDRY WORKS

Note.—(1) The data shown for tree-felling are for trees felled by cutting the roots, the stump being pulled out by the falling tree. If the tree is sawn down and the stumps and roots dug up by hand, use a multiplier of 1·50 with the labour hours shown.

(2) For grass seeding to large areas, see previous table.

Description	*Unit*	*Labour hours*
Clay puddling in 6 in. layers	Cu. yds.	7·50
Clay puddling in 9 in. layers	Cu. yds.	6·00
Fill sandbags	Each	0·25
Grass seed—prepare ground by tilthing and raking	Sq. yd.	0·20
Grass seed—sew by hand (0·07 lb. seed per sq. yd.)	Sq. yd.	0·05
Hedges—grub up and burn, 2 ft. high	Lin. yd.	1·20
Hedges—grub up and burn, 3 ft. high	Lin. yd.	1·60
Hedges—grub up and burn, 4 ft. high	Lin. yd.	1·90
Hedges—grub up and burn, 5 ft. high	Lin. yd.	2·60
Hedges—grub up and burn, 6 ft. high	Lin. yd.	3·50
Hedges—plant quicks	Each	0·05
Roll—by hand roller	Sq. yd.	0·10
Roll—by horse-drawn roller	Acre	1·00
Shrubs—planting, 2 ft. high	Each	0·25
Shrubs—planting, 3 ft. high	Each	0·40
Shrubs—planting, 4 ft. high	Each	0·55
Shrubs—planting, 5 ft. high	Each	0·70
Trees—planting young trees and staking, 10 ft. high	Each	2·00
Trees—felling, cutting up and load or burn on site, 18 in. girth	Each	16·00
Trees—felling, cutting up and load or burn on site, 36 in. girth	Each	28·00
Trees—felling, cutting up and load or burn on site, 54 in. girth	Each	42·00
Trees—felling, cutting up and load or burn on site, 72 in. girth	Each	56·00
Trees—felling, cutting up and load or burn on site, 90 in. girth	Each	69·00
Trees—felling, cutting up and load or burn on site, 108 in. girth	Each	81·00
Trees—felling, cutting up and load or burn on site, 126 in. girth	Each	92.00
Trees—felling, cutting up and load or burn on site, 144 in. girth	Each	102·00
Trim formations	Sq. yd.	0·10
Turf—strip for re-use	Sq. yd.	0·20
Turf—relay and roll	Sq. yd.	0·50

SECTION FOURTEEN

★

EXCAVATOR BELOW GROUND

In this section excavation below ground is dealt with, viz.:

1. Excavation to trenches.
2. Excavation to shafts.
3. Excavation to basements.
4. Excavation to headings.
5. Excavation to tunnels.

This section is divided into two parts, viz.:

Part One.—Excavating in Dry Ground.
Part Two.—Excavating in Wet or Water-bearing Ground.

The cubic yards excavated by a labourer per hour below ground vary greatly with the nature of the ground, for the ground may be hard, such as chalk, gravel requiring picking, soft such as sand, or wet such as "running sand". The correct estimation of the nature of the ground is of prime importance if a "sound" estimate is to be produced.

The estimator having carefully judged the nature of the ground must refer to the relevant data shown for estimating purposes.

Mechanical excavating plant is now largely used where the nature of the ground is such that mechanical plant can be used and the volume involved merits its use. Should such be the case, mechanical excavation should be adopted for in so doing the excavation is carried out at a fast rate of progress and at a cost considerably less than excavation carried out by hand.

The data shown for the excavation of shafts and basements are also applicable to excavations of a similar type such as excavation for manholes, chambers, sewage disposal works, humus tanks, etc.

Excavating Trenches, Shafts, Basements and Similar Types of Excavation by Hand

In order that the estimator may be conversant with the method and operations involved in carrying out excavation below the ground and in excavating and staging it to the surface by hand, this is dealt with in detail.

In excavating below ground a man is considered as being capable of throwing the excavated material to a height of 5 ft. or, as it is termed, in 5 ft. lifts, thus in excavating down to a depth of 5 ft. and not in excess of this the man throws the excavated material directly to the surface. In excavating at a depth greater than 5 ft., however, i.e. in the second or 5 to 10 ft. lift, the man is incapable of throwing to the surface, so a stage or platform is inserted in the excavation at a level of 5 ft. below the ground, on to which he throws the excavated material. He is thus able to excavate down to a level of 10 ft. below the ground, throwing on to this stage. The excavated material is thrown from the stage to the surface by another man, referred to as a stageman, and is cleared back from the side of the trench by a third man, so as to make room for the excavated material as it is thrown out.

This process of staging at 5 ft. intervals is continued as the depth increases, thus an excavation 10 ft. deep has a stage at a level of 5 ft. below the ground, an excavation of 15 ft. deep, one at a level of 5 ft. and one at 10 ft. below the ground and so on, the excavated material being thrown in turn from stage to stage, and finally to the surface.

One stageman per stage and one man clearing on top handle the material excavated by two men excavating in normal grounds other than rock.

In rock-bearing ground where the rate of excavation carried out by hand is slow it is uneconomical to keep stagemen standing idle waiting for the excavated material to be thrown up to them. In such cases it is usual to bar out and loosen the rock in the trench and, when a sufficient amount has been excavated, place stagemen on the stage in order to stage it to the surface. In such grounds it is wise to consider the use of compressors and pneumatic tools to break out the rock, as this greatly increases the rate of output.

In order to illustrate the "build up" of the labour hours taken per cu. yd. to excavate below ground in 5 ft. lifts, a "build up" is shown for excavating a trench in soft clay.

The estimator should note that the labour hours per cu. yd. for the various lifts are applicable to the whole volume of excavation in the lift to which they refer.

TABLE SHOWING THE "BUILD UP" OF THE LABOUR HOURS TAKEN PER CUBIC YARD TO EXCAVATE, REFILL AND RAM A TRENCH IN SOFT CLAY

Labour operations	*Labour hours per cu. yd.*			
	First lift	*Second lift*	*Third lift*	*Fourth lift*
	0 *to* 5 *ft.*	5 *to* 10 *ft.*	10 *to* 15 *ft.*	15 *to* 20 *ft.*
Excavate and throw to a 5 ft. height ..	2·10	2·10	2·10	2·10
Stage in 5 ft. lifts	—	1·05	2·10	3·15
Clear from top of trench	—	1·05	1·05	1·05
Refill and ram	1·10	1·10	1·10	1·10
Total labour hours per cu. yd.	3·20	5·30	6·35	7·40

The excavation of shafts and basements is generally "billed" in lifts of 5 ft. on a cu. yd. basis, but in the case of trench excavation excavating, refilling and ramming is usually "billed" per lin. yd. of trench at the various depths.

The method of estimating the cost of excavating, refilling and ramming trenches at any specific depth per lin. yd. of trench exclusive of timbering is as follows:

1. The cost of excavating, refilling and ramming the trench per cu. yd. for the 0 to 5, 5 to 10 and 10 to 15 lifts, etc., is estimated.
2. The volume of trench excavation in cu. yds. per lin. yd. of trench in each 5 ft. lift is assessed. Thus a trench 13 ft. deep would have 5 ft. of its depth in the 0 to 5 lift, 5 ft. in the 5 to 10 ft. lift, and 3 ft. in the 10 to 15 ft. lift.
3. The cu. yds. of excavation per lin. yd. of trench in each lift is then multiplied by the estimated cost per cu. yd. of excavating, refilling and ramming the trench in the relevant lifts, and the sum of these is the total cost per lin. yd. of trench.

The method is best illustrated by example, a typical one of which is shown giving the "build up" of the cost of the excavating, timbering, refilling and ramming a trench for pipework in sandy clay.

Example.—Estimate the cost of excavating, timbering, refilling and ramming a trench per lin. yd. in sandy clay, the depth of the trench being 12 ft. and its width 2 ft. 6 in. For purposes of this example the following prevailing rates are assumed:

Timberman's rate, 2/3 per hour.
Labourer's rate, 2/- per hour.
Initial cost of trench timber, 5/- per cu. ft.

Excavating, Refilling and Ramming the Trench per lin. yd.

The total depth of the trench is 12 ft., the depth of the various lifts being as follows:

Depth of trench in the first lift, i.e. 0–5 ft. .. .. .. = 5 ft.
Depth of trench in the second lift, i.e. 5–10 ft. .. .. .. = 5 ft.
Depth of trench in the third lift, i.e. 10–15 ft. .. .. .. = 2 ft.
Total depth of trench .. .. = 12 ft.

Referring to the table shown on p. 191, the volume of excavation per yd. run in a trench 2 ft. 6 in. wide and 12 ft. deep under the various lifts is as follows:

First lift 0–5 ft. = 1·39 cu. yds. (depth 5 ft.)
Second lift 5–10 ft. = 1·39 cu. yds. (depth 5 ft.)
Third lift 10–15 ft. = 0·55 cu. yds. (depth 2 ft.)
∴ Total = 3·33 cu. yds.

Referring to the table shown on p. 166, the labour hours taken per cu. yd. to excavate, refill and ram trenches in sandy clay at the various lifts is tabulated. These hours extended by the prevailing labour rate of 2/- per hour gives the cost of excavating, refilling and ramming the trench per cu. yd. in the various 5 ft. lifts thus:

First lift 0–5 ft., 3·20 labour hours at 2/- per hour = 76·80 pence per cu. yd.
Second lift 5–10 ft., 5·30 labour hours at 2/- per hour = 127·20 ,, ,, ,,
Third lift 10–15 ft., 6·35 labour hours at 2/- per hour = 152·40 ,, ,, ,,

Therefore the cost of excavating, refilling and ramming the trench per lin. yd., exclusive of timbering is:

First lift 0–5 ft., 1·39 cu. yds. at 76·80 pence per cu. yd. = 105·98 pence per lin. yd.
Second lift 5–10 ft., 1·39 cu. yds. at 127·20 pence per cu. yd. = 175·56 ,, ,, ,,
Third lift 10–15 ft., 0·55 cu. yds. at 152·40 pence per cu. yd. = 83·82 ,, ,, ,,
∴ The cost of excavating, refilling and ramming the trench = 365·36 ,, ,, ,,

Timbering the Trench per lin. yd.

Sandy clay comes under the category of moderately firm ground.

Referring to the table shown on p. 176, for timbering moderately firm ground the following data for estimating purposes are obtained:

1. Timberman and labourer hours timbering trench 12 ft. deep per lin. yd. = 2·16 hrs. each.
2. Quantity of timber required to timber the trench per lin. yd. = 16·00 cu. ft.
3. The "number of uses" of the timber to allow for "use and waste" = 15 No.

Since the initial cost of the timber is 5/- per cu. ft., the number of uses 15 No. and the amount required 16 cu. ft., the allowance for "use and waste" per lin. yd. of trench is:

$$\frac{5 \text{ shillings}}{15 \text{ No. uses}} \times 16{\cdot}00 \text{ cu. ft.}$$

= 64.00 pence per lin. yd.

The cost of timbering the trench per lin. yd., therefore, is:

Timberman = 2·16 hours at 2/3 per hour = 58·32 pence per lin. yd.
Labourer = 2·16 hours at 2/- per hour = 51·84 ,, ,, ,,
Allow for "use and waste" of timber = 64·00 ,, ,, ,,
∴ Cost of timbering trench .. = 174·16 ,, ,, ,,

∴ The total cost of excavating, timbering, refilling and ramming the trench per lin. yd. is:

Excavating, refilling and ramming = 365·36 pence per lin. yd.
Timbering .. .. .. = 174·16 ,, ,, ,,
Total cost .. .. .. = 539·52 ,, ,, ,,

Note.—In the above example the estimated cost per cu. yd. of the timbered excavation averaged throughout the whole depth of trench is:

The cost of excavating, timbering, refilling and ramming the trench per lin. yd. divided by the total cu. yds. of excavation in the trench per lin. yd.

$$= \frac{539 \cdot 52 \text{ pence}}{3 \cdot 33 \text{ cu. yds.}} = 162 \cdot 02 \text{ pence per cu. yd., say, } 13/6 \text{ per cu. yd.}$$

Timbering Excavations

The cost of timbering excavations is influenced by the following factors:

1. The nature of the ground and the depth of the excavation.
2. The type of excavation which has to be timbered.
3. The material cost of the timber and the assessment made as to how many times it can be used before it is unfit for further use.

This assessment influences the "allowance for use and waste", and in this connection it should be noted that the quality of the timber purchased and the treatment it receives from those who fix and remove it has much to do with its lasting properties.

The nature of the ground influences the cost, for in firm ground less timber is required than in moderately firm ground while in loose or water-bearing ground considerably more timber is necessary than in either of the cases mentioned.

Where much water has to be contended with, steel sheet piling is often resorted to in lieu of timbering, the piles being driven and the excavation removed afterwards, walings and struts being fixed to hold the piles as the excavation is proceeded with. This method of shoring excavations in water-bearing ground of large water content has much to recommend it, provided that the amount of work involved merits its adoption. It greatly simplifies the excavation and tends to speed up the work with a saving in pumping and excavation costs.

In estimating the cost of timbering, the estimator will note that the labour cost per sq. yd. of face in similar classes of ground is variable, depending upon the type of excavation and the depth.

The Allowance for "Use and Waste" of Timber

The cost of timbering is made up of two elements, viz.:

1. The labour cost of fixing and removing the timber.
2. The material cost of the timber itself.

The method of allowing for the material cost of the timber, knowing its initial cost per cu. ft. is as follows:

1. The number of times the timber can be used before it is unfit for further use is assessed.
2. The cost of the timber is allowed for by dividing its initial cost per cu. ft. by the assessed number of times it can be used, and "writing it off" in the rates tendered for the timbering of the excavations.

   e.g. Assuming the initial cost of the timber is 5/- per cu. ft. and it is assessed that for purposes of estimating it can be used 10 No. times.

   The allowance for "use and waste" $= \frac{5/-}{10} =$ 6*d.* per cu. ft. This 6*d.* per cu. ft. multiplied by the cu. ft. of timber required per lin. yd. of trench or per sq. yd. of face in the case of shafts, basements and tunnels, is the allowance to make in the estimate for the "use and waste" of the timber concerned.

In connection with the timbering of tunnels the estimator should carefully note if allowance has to be made for leaving it in the tunnel in whole or in part, and if so, allow for its cost accordingly. In many instances no mention is made as to whether the timber has to be left in or not, and the onus of deciding how much timber can be removed, if any, is put upon the estimator, who must assess this for himself, taking into consideration the probable nature of the ground.

In assessing the amount of timber recoverable from a tunnel, it is wise to err on the side of safety, this being done by not setting too high a value on the number of uses which may be expected from it.

The Tables shown for Estimating Purposes.

The tables shown for estimating purposes are as follows:

1. Excavate trenches in dry ground by hand.
2. Excavate trenches in rock, using compressors and pneumatic tools.
3. Excavate trenches, using mechanical excavating plant of the backacter and endless bucket type.
4. Timber trenches in dry ground.
5. Excavate shafts and basements in dry ground by hand.
6. Excavate shafts and basements in dry ground, using jack rolls or hand winches.
7. Excavate shafts and basements in dry ground, using power-driven cranes.
8. Timber shafts and basements in dry ground.
9. Refill and ram excavations by hand.
10. Excavate tunnels, using jack rolls or hand winches.
11. Excavate tunnels, using power-driven cranes.
12. Timber tunnels.
13. Refill and ram tunnels.
14. Excavating headings.
15. Excavate trenches in water-bearing ground.
16. Timber trenches in water-bearing ground.
17. Excavate shafts and basements in water-bearing ground.
18. Timber shafts and basements in water-bearing ground.
19. Output of diaphragm, centrifugal and pulsometer pumps in gallons per minute.
20. The volume of excavation displaced by pipes of various diameters per lin yd.
21. Trench timber. The lin. ft. of timber of various sizes per standard of 165 cu. ft.
22. The volume of excavation in trenches of various depths and widths per lin yd.

In connection with these tables the following should be noted:

(*a*) Separate tables are shown for excavating and for timbering the excavations.

(*b*) The data shown do not include for loading and transporting any excavated or surplus material to tip. For this the estimator is referred to Section Thirteen, "Excavator Above Ground", where data are shown from which this may be estimated.

(*c*) The cost of excavating tunnels of various depths below ground and lengths from the shafts is allowed for by the use of multipliers in conjunction with the data shown in the main estimating tables for tunnel work.

(*d*) No breaking out of hard surfaces such as roads, etc., or the reinstatement of surfaces is allowed for. For breaking out hard surfaces, see Section Thirteen, "Excavator Above Ground", p. 149, and for the reinstatement of surfaces, Section Twenty-four, "Roadmaker".

(*e*) The data shown for timbering shafts and basements in dry ground are for timbering in lifts of 5 ft. and for depths from 0 to 50 ft. deep below the ground per sq. yd. of face. The data have been shown in lifts of 5 ft. as it is standard practice to "bill" the timbering of this type of excavation in this manner. The data shown for depths ranging from 0 to 50 ft. are of particular use for deep work such as tunnel shafts, etc.

(*f*) In the data shown for timbering:

Firm ground refers to such ground as firm sand, gravel and compact soils which, when excavated, stand up well without a tendency to slip or collapse.

Moderately firm ground refers to such grounds as soft or sandy clay, loamy soil, marl, clay and gravel which have to be timbered within a reasonable space of time after the ground has been excavated in order to prevent collapse.

Loose ground, as the term implies, refers to ground which will not stand up when excavated, necessitating its being securely timbered.

Water-bearing ground refers to gravel, sand and chalk with water present.

The tables shown for timbering state the cu. ft. of timber required per lin. yd. of trench or per sq. yd. of face, as the case may be, the "number of uses" also being shown, and these may be used as they stand for estimating purposes.

The method of using the tables is fully illustrated, examples being shown of how to "build up" the cost of excavating and timbering excavations of various types.

PART ONE

EXCAVATOR BELOW GROUND—DRY

Excavate Trenches, using Mechanical Excavating Plant of the Backacter and Endless Bucket Type

In suitable ground and where the volume and depth of excavation merits it the excavation of trenches is commonly carried out by suitable mechanical plant.

Two types of machines are used for excavating trenches, viz.:

1. Mechanical excavating plant of the backacter type.
2. Mechanical excavating plant of the endless bucket type.

The backacter type of plant consists of a mechanical excavator fitted with "backacter" equipment. The same plant may be fitted with equipment other than the backacter, such as shovel, skimmer, dragline, etc. The plant, is therefore, useful in

EXCAVATE, REFILL AND RAM TRENCHES BY HAND IN DRY GROUND

Note.—(1) The labour hours shown are those taken to excavate, refill and ram trenches per cu. yd. for the various lifts, exclusive of timbering, the excavated material being staged to the surface.

(2) The labour hours shown for the various lifts are applicable to the whole volume of excavation contained in the lift to which they refer. See example, p. 166.

(3) For timbering trenches, see p. 176.

(4) For excavating trenches in rock, using compressors and pneumatic tools, see p. 171.

(5) For excavating trenches, using mechanical excavating plant of the backacter or endless bucket type, see pp. 174–6.

(6) The rock referred to is rock with many fissures and of a stratified nature.

Depth of excavation in feet	*Nature of ground and labour hours excavating, refilling and ramming trenches in lifts of 5 ft. Per cu. yd.*						
	Firm sand	*Loamy soil, soft or sandy clay or marl*	*Stiff clay*	*Gravel or compact ground requiring picking*	*Chalk*	*Soft stratified fissured rock*	*Hard stratified fissured rock*
First lift, 0 to 5 ft.	2·80	3·20	3·50	3·60	4·40	6·40	8·40
Second lift, 5 to 10 ft.	4·70	5·30	5·80	6·20	7·60	9·60	11·80
Third lift, 10 to 15 ft.	5·65	6·35	6·95	7·50	9·20	11·20	13·50
Fourth lift, 15 to 20 ft.	6·60	7·40	8·10	8·80	10·80	12·80	15·20

EXCAVATE, REFILL AND RAM TRENCHES IN ROCK, USING COMPRESSORS AND PNEUMATIC TOOLS

Note.—(1) The plant and labour hours shown are those taken to break out, excavate, refill and ram the trench per cu. yd., the excavated material being staged to the surface.

(2) The plant and labour hours shown for the various lifts are applicable to the whole volume of excavation contained in the lift to which they refer.

(3) The data shown are for a 2-tool compressor with two tools in use. If a 3-tool compressor is used the compressor hours per cu. yd. are two-thirds of those shown, the labour hours on tools and the labour hours remaining the same.

(4) In the case of stratified fissured rocks little or no timbering of the trench is necessary, but on occasions a pair of poling boards held by a strut may be required here and there if there is a tendency for isolated slips or falls to occur.
In the case of solid rock no timbering is required.

(5) The stratified fissured rock referred to is soft and hard rocks with many fissures, capable of being readily broken out by pneumatic tools. The solid rock is for rock in solid beds, which definitely necessitates the use of pneumatic tools or blasting to remove it economically.

EXCAVATE, REFILL AND RAM TRENCHES IN ROCK, USING 2-TOOL COMPRESSORS

Depth of excavation in feet	*Nature of ground and compressor and labour hours excavating, refilling and ramming trenches in lifts of 5 ft. Per cu. yd.*								
	Soft stratified fissured rock			*Hard stratified fissured rock*			*Solid rock*		
	Compressor hours	*Labour hours on pneumatic tools*	*Labour hours*	*Compressor hours*	*Labour hours on pneumatic tools*	*Labour hours*	*Compressor hours*	*Labour hours on pneumatic tools*	*Labour hours*
First lift 0 to 5 ft. ..	0·30	0·60	3·60	0·40	0·80	4·40	1·70	3·40	4·80
Second lift, 5 to 10 ft. ..	0·33	0·66	6·00	0·44	0·88	7·60	1·87	3·74	8·40
Third lift, 10 to 15 ft.	0·36	0·72	7·20	0·48	0·96	9·20	2·04	4·08	10·20
Fourth lift, 15 to 20 ft.	0·39	0·78	8·40	0·52	1·04	10·80	2·20	4·40	12·00

that it is universal and capable of being used on classes of work other than trenching simply by fitting the other attachments.

The trench excavated by a backacter tends to be rough on the face, necessitating a certain amount of trimming prior to carrying out the timbering, this roughness being due to the action of the bucket, which drags the sides as the machine excavates. This type of plant is capable of excavating trenches in suitable ground to a depth of approximately 12 ft.

The endless bucket plant, sometimes referred to as "trenching plant", is designed solely for use in excavating trenches. It works on the principle of a dredger and, in suitable ground, cuts a clean trench with smooth faces, necessitating little or no trimming before the timbering is fixed in position. These machines are available in two main types:

1. Plant capable of excavating trenches to a depth of approximately 5 ft., such as the Allen Parson's 12/18, etc.
2. Plant capable of excavating trenches to a depth of approximately 14 ft., such as the Allen Parson's 16/60, etc.

The timbering of trenches carried out by mechanical excavating plant usually consists of runners, these being placed in position immediately behind the machine as it excavates, where they are held in position by struts. The runners may then be securely held afterwards if required by walings. The runners are generally well spaced (depending on the nature of the ground) and the timbering is of a comparatively light nature. For normal conditions and grounds the data shown for timbering trenches in firm ground on p. 176 should be used for estimating purposes.

The plant hours shown are not based on the maximum outputs of these machines, but on what has been found from experience to be a "fair average" output. By referring to the table the estimator will note that the plant hours per cu. yd. decrease with the depth down to approximately 5 ft. below the ground at which depth they commence to increase, this being due to the fact that the output of these machines increases with the depth down to 5ft., after which it falls away as timbering has to be carried out and care taken to secure the sides of the excavation as the excavation proceeds. At the greater depths the machine cannot be allowed to run too far ahead until the timber is in position, all of which tends to reduce the output.

The Tables shown for use in Estimating the Cost of Excavating, Refilling, Ramming and Timbering Trenches, using Mechanical Excavating Plant

In connection with the tables shown for estimating purposes the estimator should note the following:

1. The tables shown for excavating, refilling and ramming the trenches, using backacters and endless bucket type plant, give the plant and labour hours per cu. yd., the labour hours shown allowing for trimming the trench bottom to levels and falls and refilling and ramming the trenches by hand.
2. The table shown for timbering trenches gives the timberman and labourer hours taken to fix and remove the timber per lin. yd. of trench, both sides of the trench being allowed for in the hours shown. In order that the "use and waste" of timber may be allowed for, the number of uses of the timber is stated as is the amount of timber required per lineal yard of trench.

To illustrate the use of the tables the following example is shown:

Example.—Estimate the cost of excavating, timbering, refilling and ramming a trench per lin. yd. in sandy clay, using an Allen Parson's 16/60 endless bucket type plant, the depth of trench being 9 ft. and its width 2 ft. 6 in. The following prevailing rates are assumed for purposes of this example:

Hire rate or working cost per hour of an Allen Parson's 16/60 trenching plant, inclusive of driver, fuel and oil	14/6 per hour
Timberman's rate	2/3 „
Labourer's rate	2/- „
Initial cost of trench timber	5/- cu. ft.

Excavating, refilling and ramming the trench per lin. yd.

Referring to the table shown on p. 191, the volume of excavation to be excavated per lin. yd. in a trench of 2 ft. 6 in. wide and 9 ft. deep is 2·50 cu. yds.

Referring to the table shown on p. 175, the cost of excavating, refilling and ramming per cu. yd. at 9 ft. deep, using an Allen Parson's 16/60 machine, is:

Allen Parson's 16/60 = 0·073 hrs. at 14/6 per hr. = 12·70 pence per cu. yd.
Labour hours = 1·75 hrs. at 2/- per hr. = 42·00 „ „ „
54·70 „ „ „

∴ The cost of excavating the trench per lin. yd. = 2·50 cu. yds. at 54·70 pence per cu. yd.
= 136·75 pence per lin. yd.

Timbering the Trench per lin. yd.

Referring to the table shown on p. 176, for timbering in firm ground the following data for estimating purposes are found:

1. Timberman and labour hours timbering a trench 9 ft. deep per lin. yd. = 0·37 hr. each.
2. Quantity of timber required to timber the trench per lin. yd. = 6·00 cu. ft.
3. The "number of uses" of the timber to allow for "use and waste" = 15 No.

Since the initial cost of timber is 5/- per cu. ft., the number of uses 15 No., and the amount required 6·00 cu. ft., the allowance for "use and waste" per lin. yd. of trench is:

$$\frac{5 \text{ shillings}}{15 \text{ No. uses}} \times 6{\cdot}00 \text{ cu. ft.} = 24{\cdot}00 \text{ pence per lin. yd.}$$

The cost of timbering the trench per lin. yd., therefore, is:

Timberman, 0·37 hr. at 2/3 per hour = 9·99 pence per lin. yd.
Labourer, 0·37 hr. at 2/- per hour = 8·88 ,, ,, ,,
Allow for "use and waste" of timber = 24·00 ,, ,, ,,
∴ Cost of timbering trench = 42·87 ,, ,, ,,

The total cost of excavating, timbering, refilling and ramming the trench per lin yd. then is:

Excavating, refilling and ramming = 136·75 pence per lin. yd.
Timbering . . . . . . = 42·87 ,, ,, ,,
Total cost . . . . . . = 179·62 ,, ,, ,,
Say 15/- per lin. yd.

In the above example the estimated cost of the timbered excavation averaged throughout the trench per cu. yd. is:

The cost of excavating, timbering, refilling and ramming the trench per lin. yd. divided by the total cu. yds. of excavation in the trench per lin. yd.

$$= \frac{179{\cdot}62 \text{ pence per cu. yd.}}{2{\cdot}50}$$

= 71·85 pence per cu. yd.
Say 6/- per cu. yd.

Note.—In the example shown, the cost of hauling the plant has not been allowed for.

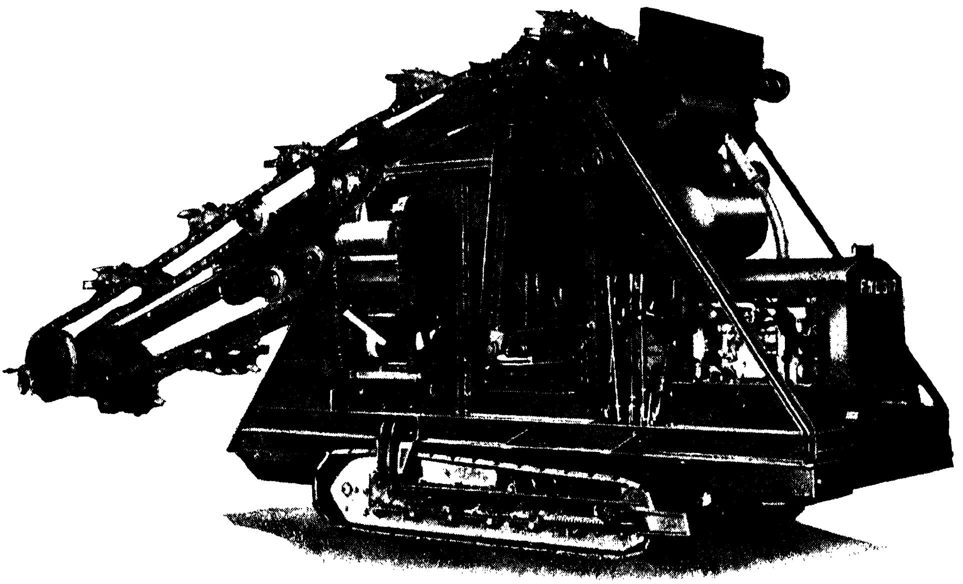


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FIG. 22.—TRENCH EXCAVATOR OF THE ENDLESS BUCKET TYPE FOR TRENCHES FROM 2 FT. TO 5 FT. WIDE AND APPROXIMATELY 12 FT. DEEP

EXCAVATE, REFILL AND RAM TRENCHES, USING MECHANICAL EXCAVATING PLANT OF THE "BACKACTER" TYPE

Note.—(1) The data show the plant and labour hours taken to excavate, refill and ram trenches per cu. yd., the refilling and ramming being carried out by hand.

(2) The plant and labour hours shown at the various depths are applicable to the whole volume of excavation from ground level to the depths shown.

(3) The hours shown do *not* include for timbering, for which see p. 176, the data shown for timbering in firm ground being applicable.

¼ CU. YD. BACKACTER

Depth of trench in feet	*Nature of ground and plant and labour hours excavating, refilling and ramming trenches. Per cu. yd.*									
	Firm sand		*Loamy soil, soft or sandy clay or marl*		*Gravel*		*Stiff clay*		*Chalk*	
	Plant hours	*Labour hours*	*Plant hours*	*Labour hours*	*Plant hours*	*Labour hours*	*Plant hours*	*Labour hours*	*Plant hours*	*Labour hours*
1	0·100	1·70	0·140	2·38	0·150	2·55	0·170	2·90	0·200	3·40
2	0·097	1·64	0·135	2·30	0·145	2·46	0·164	2·79	0·194	3·28
3	0·093	1·58	0·130	2·21	0·140	2·38	0·158	2·69	0·186	3·16
4	0·090	1·53	0·126	2·14	0·135	2·30	0·153	2·60	0·180	3·06
5	0·087	1·48	0·122	2·07	0·130	2·21	0·148	2·52	0·174	2·96
6	0·090	1·53	0·126	2·14	0·135	2·30	0·153	2·60	0·180	3·06
7	0·093	1·58	0·130	2·21	0·140	2·38	0·158	2·69	0·186	3·16
8	0·097	1·64	0·134	2·30	0·145	2·46	0·161	2·79	0·194	3·28
9	0·100	1·70	0·140	2·38	0·150	2·55	0·170	2·90	0·200	3·40
10	0·102	1·75	0·143	2·44	0·154	2·62	0·174	2·97	0·204	3·50
11	0·105	1·80	0·147	2·50	0·158	2·69	0·178	3·03	0·210	3·60
12	0·108	1·85	0·151	2·57	0·162	2·75	0·182	3·09	0·216	3·70

⅜ CU. YD. BACKACTER

Depth of trench in feet	*Nature of ground and plant and labour hours excavating, refilling and ramming trenches. Per cu. yd.*									
	Firm sand		*Loamy soil, soft or sandy clay or marl*		*Gravel*		*Stiff clay*		*Chalk*	
	Plant hours	*Labour hours*	*Plant hours*	*Labour hours*	*Plant hours*	*Labour hours*	*Plant hours*	*Labour hours*	*Plant hours*	*Labour hours*
1	0·068	1·63	0·096	2·30	0·102	2·45	0·115	2·76	0·136	3·26
2	0·066	1·58	0·093	2·23	0·099	2·37	0·112	2·69	0·132	3·16
3	0·064	1·53	0·090	2·16	0·096	2·30	0·109	2·62	0·128	3·06
4	0·062	1·48	0·087	2·09	0·093	2·23	0·106	2·55	0·124	2·96
5	0·060	1·44	0·084	2·02	0·090	2·16	0·103	2·48	0·120	2·88
6	0·062	1·48	0·087	2·09	0·093	2·23	0·106	2·55	0·124	2·96
7	0·064	1·53	0·090	2·16	0·096	2·30	0·109	2·62	0·128	3·06
8	0·066	1·58	0·093	2·23	0·099	2·37	0·112	2·69	0·132	3·16
9	0·068	1·63	0·096	2·30	0·102	2·45	0·115	2·76	0·136	3·26
10	0·070	1·68	0·099	2·37	0·105	2·52	0·119	2·85	0·140	3·36
11	0·072	1·73	0·102	2·44	0·108	2·59	0·123	2·95	0·144	3·46
12	0·074	1·78	0·105	2·52	0·111	2·66	0·127	3·05	0·148	3·56

½ CU. YD. BACKACTER

Depth of trench in feet	Nature of ground and plant and labour hours excavating, refilling and ramming trenches. Per cu. yd.									
	Firm sand		Loamy soil, soft or sandy clay or marl		Gravel		Stiff clay		Chalk	
	Plant hours	Labour hours	Plant hours	Labour hours	Plant hours	Labour hours	Plant hours	Labour hours	Plant hours	Labour hours
1	0·052	1·56	0·074	2·22	0·080	2·40	0·090	2·70	0·104	3·12
2	0·051	1·53	0·072	2·16	0·078	2·34	0·088	2·64	0·102	3·06
3	0·050	1·50	0·070	2·10	0·076	2·28	0·086	2·58	0·100	3·00
4	0·049	1·47	0·068	2·04	0·074	2·22	0·084	2·52	0·098	2·94
5	0·048	1·44	0·066	1·98	0·072	2·16	0·082	2·46	0·096	2·88
6	0·049	1·47	0·068	2·04	0·074	2·22	0·084	2·52	0·098	2·94
7	0·050	1·50	0·070	2·10	0·076	2·28	0·086	2·58	0·100	3·00
8	0·051	1·53	0·072	2·16	0·078	2·34	0·088	2·64	0·102	3·06
9	0·052	1·56	0·074	2·22	0·080	2·40	0·090	2·70	0·104	3·12
10	0·053	1·59	0·076	2·28	0·082	2·46	0·092	2·76	0·106	3·18
11	0·054	1·62	0·078	2·34	0·084	2·52	0·094	2·82	0·108	3·24
12	0·055	1·65	0·080	2·40	0·086	2·58	0·096	2·88	0·110	3·30

EXCAVATE, REFILL AND RAM TRENCHES, USING MECHANICAL EXCAVATING PLANT OF THE "ENDLESS BUCKET" TYPE

Note.—(1) The data show the plant and labour hours taken to excavate, refill and ram trenches per cu. yd., the refilling and ramming being carried out by hand.

(2) The plant and labour hours shown at the various depths are applicable to the whole volume of excavation from ground level to the depths shown.

(3) The hours shown do *not* include for timbering, for which see p. 176, the data shown for timbering in firm ground being applicable.

ALLEN PARSON'S 16/60 OR BARBER GREEN TYPE 44C

Depth of trench in feet	Nature of ground and plant and labour hours excavating, refilling and ramming trenches. Per cu. yd.									
	Firm sand		Loamy soil, soft or sandy clay or marl		Gravel		Stiff clay		Chalk	
	Plant hours	Labour hours	Plant hours	Labour hours	Plant hours	Labour hours	Plant hours	Labour hours	Plant hours	Labour hours
1	0·068	1·63	0·096	2·30	0·102	2·45	0·116	2·78	0·136	3·26
2	0·064	1·53	0·090	2·16	0·096	2·30	0·109	2·62	0·128	3·06
3	0·060	1·44	0·084	2·00	0·090	2·16	0·102	2·45	0·120	2·88
4	0·056	1·34	0·078	1·87	0·084	2·00	0·095	2·28	0·112	2·68
5	0·052	1·25	0·073	1·75	0·078	1·87	0·089	2·14	0·104	2·50
6	0·049	1·18	0·069	1·66	0·074	1·78	0·084	2·00	0·098	2·36
7	0·047	1·11	0·066	1·58	0·070	1·68	0·080	1·92	0·094	2·22
8	0·049	1·18	0·069	1·66	0·074	1·78	0·084	2·00	0·098	2·36
9	0·052	1·25	0·073	1·75	0·078	1·87	0·089	2·14	0·104	2·50
10	0·056	1·34	0·078	1·87	0·084	2·00	0·095	2·28	0·112	2·68
11	0·060	1·44	0·084	2·00	0·090	2·16	0·120	2·45	0·120	2·88
12	0·064	1·53	0·090	2·16	0·096	2·30	0·109	2·62	0·128	3·06

ALLEN PARSON'S 12/18 OR CLEVELAND TYPE

Depth of trench in feet	*Nature of ground and plant and labour hours excavating, refilling and ramming trenches. Per cu. yd.*									
	Firm sand		*Loamy soil, soft or sandy clay or marl*		*Gravel*		*Stiff clay*		*Chalk*	
	Plant hours	*Labour hours*	*Plant hours*	*Labour hours*	*Plant hours*	*Labour hours*	*Plant hours*	*Labour hours*	*Plant hours*	*Labour hours*
1	0·053	1·54	0·074	2·15	0·080	2·32	0·090	2·61	0·106	3·07
2	0·050	1·45	0·070	2·03	0·075	2·17	0·085	2·46	0·100	2·90
3	0·046	1·33	0·065	1·89	0·069	2·00	0·078	2·26	0·092	2·66
4	0·043	1·25	0·060	1·74	0·065	1·88	0·073	2·12	0·086	2·50
5	0·057	1·65	0·080	2·32	0·085	2·46	0·096	2·75	0·114	3·30

TIMBERING TRENCHES IN DRY GROUND

Note.– (1) The timberman and labourer hours shown are those taken to timber the trench per lin. yd., both sides of the trench being allowed for in the hours shown.

(2) The data shown allow for both fixing and removing the timber.

(3) The cu. ft. of timber shown represents the total cu. ft. of timber required to timber the trench per lin. yd., both sides of the trench being allowed for. For purposes of estimating, allow for "use and waste" of timber 15 No. uses.

Depth of trench in feet	*Nature of ground, cu. ft. of timber required to timber trench, and timberman and labour hours timbering trenches. Per lin. yd.*								
	Firm ground			*Moderately firm ground*			*Loose ground*		
	Timber cu. ft.	*Timberman hrs.*	*Labour hours*	*Timber cu. ft.*	*Timberman hrs.*	*Labour hours*	*Timber cu. ft.*	*Timberman hrs.*	*Labour hours*
3	2·00	0·09	0·09	4·00	0·36	0·36	6·60	0·79	0·72
4	2·66	0·13	0·13	5·33	0·50	0·50	8·78	1·00	1·00
5	3·33	0·17	0·17	6·66	0·66	0·66	10·98	1·33	1·33
6	4·00	0·21	0·21	8·00	0·84	0·84	13·20	1·68	1·68
7	4·66	0·26	0·26	9·33	1·02	1·02	15·38	2·05	2·05
8	5·33	0·31	0·31	10·66	1·22	1·22	17·60	2·45	2·45
9	6·00	0·37	0·37	12·00	1·44	1·44	19·80	2·88	2·88
10	6·66	0·44	0·44	13·33	1·66	1·66	21·98	3·33	3·33
11	7·33	0·50	0·50	14·66	1·90	1·90	24·18	3·81	3·81
12	8·00	0·57	0·57	16·00	2·16	2·16	26·40	4·33	4·33
13	8·66	0·64	0·64	17·33	2·42	2·42	28·60	4·85	4·85
14	9·33	0·72	0·72	18·66	2·70	2·70	30·78	5·41	5·41
15	10·00	0·80	0·80	20·00	3·00	3·00	33·30	6·00	6·00
16	10·66	0·88	0·88	21·33	3·30	3·30	35·17	6·61	6·61
17	11·33	0·98	0·98	22·66	3·62	3·62	37·40	7·25	7·25
18	12·00	1·07	1·07	24·00	3·96	3·96	39·60	7·92	7·92
19	12·66	1·16	1·16	25·33	4·30	4·30	41·78	8·60	8·60
20	13·33	1·26	1·26	26·66	4·66	4·66	44·00	9·33	9·33

Excavating Shafts, Basements and Excavations of a Similar Type

Under the above heading may be classed excavations carried out in connection with shafts, manholes, small chambers, basements, pump chambers, underground tanks, such as humus and sedimentation tanks, etc.

The method of excavating is governed to a large extent by the area of the excavation, and, in general, is carried out in one of three ways, viz.:

(*a*) Excavating by hand and staging the excavated material to the surface.

(*b*) Where the area of the excavation is not excessive, excavating by hand and hoisting the excavated material to the surface by jack roll or hand winch. This method is commonly used in excavating shafts.

(*c*) Excavating by hand and hoisting the excavated material to the surface by power-driven crane and skips.

In carrying out excavations of the basement type of sufficiently large area the estimator should note that it may be possible to do so, using a combination of plant. Thus, if the area and the volume of excavation merits it, the whole or part of the excavation may be removed by a mechanical excavator of the dragline type. In the event of the excavation being of such depth that the dragline cannot wholly remove it, on account of the sides falling in, it may be used to excavate to the maximum possible depth, after which a power-driven crane may be used with skips to complete the excavation. A combination such as this would, in suitable circumstances, carry out the excavation at considerably less cost than were it carried out wholly by crane and skips.

In using a power-driven crane to hoist the excavated material, a point which should be borne in mind is that the crane hours per cu. yd. of excavation is governed by the number of men excavating, for if the area of the excavation is such that four men can excavate, the crane hours per cu. yd. are only one-half of what they would be were two men excavating.

Timbering Shafts, Basements and Excavations of a Similar Type

Depending upon the area of the excavation the cost of timbering per sq. yd. of face varies, it being greater in the case of excavations of large area than of small. For purposes of estimating, tables are shown for timbering both shafts and basements, the data shown for shafts may be taken as applying to excavations whose area is not in excess of 20 sq. yds. and that for basements for excavations of areas in excess of this.

Excavation and timbering to excavations of the shaft and basement type are generally "billed" in lifts of 5 ft., the excavation being in cu. yds. and the timbering per sq. yd. of face. On occasions an "all-in" rate has to be quoted for the timbered excavation per cu. yd., in which case the cost of excavating and timbering the excavation as a whole must be assessed, which cost, divided by the total cu. yds. of excavation gives the estimated cost of the timbered excavation per cu. yd.

The Tables shown for use in Estimating the Cost of Excavating and Timbering Excavations of the Shaft and Basement Type

For estimating purposes the following tables are shown:

1 Excavate shafts and basements by hand and stage the excavated material to the surface.
2. Excavate shafts and basements by hand and hoist to the surface by jack roll or hand winch.
3. Excavate shafts and basements by hand and hoist to the surface by power-driven crane.
4. Timber shafts and basements in lifts of 5 ft.
5. Timber shafts and basements at depths ranging from 0 to 50 ft.
6. Refill and ram excavations.

Knowing the nature of the ground, the depth, the type of excavation and the volume involved, the estimator must decide on the most suitable method to adopt in carrying out the excavation and base the estimate of the cost accordingly.

The data shown in the table for excavations does not allow for the breaking out of hard surfaces, such as roads, nor for the reinstatement of surfaces. The estimator is referred to Section Thirteen, "Excavator Above Ground", p. 149, where data are given for breaking out hard surfaces, and to Section Twenty-four, "Roadmaker", where data are shown for the reinstatement of surfaces. The reinstatement of footways is dealt with in Section Sixteen, "Mason", p. 203.

For excavating large excavations of the pit type by mechanical excavating plant of the dragline and shovel type, reference should be made to Section Thirteen, "Excavator Above Ground", p. 153.

In order to illustrate the method of using the tables in "building up" an estimate of the cost of this type of excavation a typical example is shown.

Example.—A manhole has to be excavated in sandy clay, the dimensions of the excavation being 6 ft. × 4 ft. 6 in. × 9 ft. deep. The excavation is to be carried out by hand and staged to the surface. Estimate the cost of the following:

1. The excavation per cu. yd. at the various 5 ft. lifts.
2. The timbering per sq. yd. at the various 5 ft. lifts.
3. The cost of the timbered excavation per cu. yd.

For purposes of this example the following rates are assumed:

Timberman's rate = 2/3 per hour.
Labourer's rate = 2/- per hour.
Material cost of timber used for timbering the excavation = 5/- per cu. ft.

Excavating and Staging to the Surface per cu. yd.

Referring to the table shown on p. 179, the labour hours taken to excavate and stage sandy clay per cu. yd. at the various lifts is shown. The labour rate being 2/- per hour, the cost per cu. yd. at the various lifts is given by:

First lift 0–5 ft., 2·30 labour hrs. at 2/- per hr. = 55·20 pence per cu. yd.
Second lift 5–10 ft., 4·80 labour hrs. at 2/- per hr. = 115·20 ,, ,, ,,

Timbering per sq. yd.

Sandy clay comes under the category of moderately firm ground.

Referring to the table shown on p. 182, the following data for timbering in moderately firm ground are obtained:

1. Timberman and labourer hours timbering shafts per sq. yd. at 5 ft. lifts:

	First lift 0–5 ft.	Second lift 5–10 ft.
Timberman hours	0·30	0·40
Labourer hours	0·30	0·40

2. Timber required per sq. yd. in moderately firm ground = 2·00 cu. ft.
3. No. of uses of timber to allow for "use and waste" = 12 No.

In the case of this example the timber costs 5/- per cu. ft., the amount required per sq. yd. is 2·00 cu. ft. and the number of uses is 12 No.

∴ The allowance for "use and waste" of timber per sq. yd. $= \dfrac{5/-}{12 \text{ No. uses}} \times 2{\cdot}00$ cu. ft.
= 10*d*. per sq. yd.

The cost of timbering per sq. yd., therefore, is:

First Lift 0 *to* 5 *feet*

Timberman, 0·30 hr. at 2/3 per hr. = 8·10 pence per sq. yd.
Labourer, 0·30 hr. at 2/- per hr. = 7·20 ,, ,, ,,
Allow for "use and waste" of timber = 10·00 ,, ,, ,,
∴ Cost of timbering 0–5 ft. .. .. = 25·30 ,, ,, ,,

Second Lift 5 *to* 10 *feet*

Timberman, 0·40 hr. at 2/3 per hr. = 10·80 pence per sq. yd.
Labourer, 0·40 hr. at 2/- per hr. = 9·60 ,, ,, ,,
Allow for "use and waste" of timber = 10·00 ,, ,, ,,
∴ Cost of timbering 5–10 ft.. .. = 30·40 ,, ,, ,,

The Cost of the Timbered Excavation per cu. yd.

. The above is found by assessing the cost of the total volume of excavation and the total sq. yds. of timbering, and dividing the total cost of these two by the total cu. yds. of excavation.

The excavation in the first or 0 to 5 ft. lift = 6 ft. × 4 ft. 6 in. × 5 ft. = 5 cu. yds.
The excavation in the second or 5 to 10 ft. lift = 6 ft. × 4 ft. 6 in. × 4 ft. = 4 cu. yds.
The timbering in the first or 0 to 5 ft. lift = 5 {2 (6 ft. + 4 ft. 6 in.)} = 105 sq. ft. = 11·66 sq. yds.
The timbering in the second or 0 to 10 ft. lift = 4 {2 (6 ft. + 4 ft. 6 in.)} = 84 sq. ft. = 9·33 sq. yds.

∴ The total cost of the timbered excavation is:

Excavate the first lift	(5 ft. deep) =	5 cu. yds.	at 55·20 pence =	276·00 pence
Excavate the second lift	(4 ft. deep) =	4 cu. yds.	at 115·20 pence =	460·80 "
Timbering the first lift	(5 ft. deep) =	11·66 sq. yds.	at 25·30 pence =	295·00 "
Timbering the second lift	(4 ft. deep) =	9·33 sq. yds.	at 30·40 pence =	283·63 "
∴ Total cost of the timbered excavation	..	..	.. .. =	1315·43 "
			=	£5 9s. 7d.

The total cu. yds. of excavation = 9 cu. yds.

The cost of the timbered excavation £5 9s. 7d.

= 12/2 per cu. yd.

Note.—In the above example no allowance has been made for refilling and ramming, if any, or loading and hauling the excavated material to tip.

For refilling and ramming, the estimator is referred to p. 183, while loading and hauling the excavation to tip is dealt with in Section Thirteen, "Excavator Above Ground", pp. 155–7.

EXCAVATE SHAFTS AND BASEMENTS BY HAND IN DRY GROUND

Note.—(1) The labour hours shown are those taken to excavate shafts and basements and similar types of excavation per cu. yd. for the various lifts, exclusive of timbering, the excavated material being staged to the surface.

(2) The labour hours shown for the various lifts are applicable to the whole volume of excavation contained in the lift to which they refer. See example, p. 166.

(3) For timbering shafts and basements, see pp. 182 and 183.

(4) For refilling and ramming, see p. 183.

(5) For excavating shafts and basements, using jack rolls, hand winches, or power-driven cranes to hoist the excavated material, see pp. 180 and 181.

(6) For loading and transporting the excavated material to tip, the estimator is referred to Section Thirteen, "Excavator Above Ground", pp. 155–7.

(7) The rock referred to is rock with many fissures and of a stratified nature.

Depth of excavation in feet	*Nature of ground and labour hours excavating shafts and basements in lifts of 5 ft. Per cu. yd.*						
	Firm sand	*Loamy soil, soft or sandy clay or marl*	*Stiff clay*	*Gravel or compact ground requiring picking*	*Chalk*	*Soft stratified fissured rock*	*Hard stratified fissured rock*
First lift, 0 to 5 ft.	2·20	2·30	2·50	2·80	3·60	5·70	7·90
Second lift, 5 to 10 ft.	4·50	4·80	5·30	5·90	7·50	9·60	12·00
Third lift, 10 to 15 ft.	5·65	6·05	6·70	7·45	9·40	11·50	14·10
Fourth lift, 15 to 20 ft.	6·80	7·30	8·10	9·00	11·30	13·40	16·20

EXCAVATE SHAFTS AND BASEMENTS IN ROCK, USING COMPRESSORS AND PNEUMATIC TOOLS

Note.—(1) The plant and labour hours shown are those taken to break out, excavate and stage to the surface per cu. yd.

(2) The plant and labour hours shown for the various lifts are applicable to the whole volume of excavation contained in the lift to which they refer.

(3) The data shown are for a 2-tool compressor with two tools in use. If a 3-tool compressor is used the compressor hours per cu. yd. are two-thirds of those shown, the labour hours on tools and the labour hours remaining the same.

(4) In the case of stratified fissured rocks little or no timbering is necessary, but on occasions poling boards, well spaced, may be required if there is a tendency for slips or falls to occur. In the case of solid rock no timbering is required.

(5) The stratified fissured rock referred to is soft and hard rock with many fissures, capable of being readily broken out by pneumatic tools. The solid rock is for rock in solid beds, which definitely necessitates the use of pneumatic tools or blasting to remove it economically.

EXCAVATE SHAFTS AND BASEMENTS IN ROCK, USING 2-TOOL COMPRESSORS

Depth of excavation in feet	*Nature of ground and compressor and labour hours excavating shafts and basements in lifts of 5 ft. Per cu. yd.*								
	Soft stratified fissured rock			*Hard stratified fissured rock*			*Solid rock*		
	Compressor hours	*Labour hours on pneumatic tools*	*Labour hours*	*Compressor hours*	*Labour hours on pneumatic tools*	*Labour hours*	*Compressor hours*	*Labour hours on pneumatic tools*	*Labour hours*
First lift, 0 to 5 ft. ..	0·36	0·72	3·00	0·48	0·96	4·00	2·06	4·12	4·50
Second lift, 5 to 10 ft.	0·39	0·78	5·80	0·53	1·06	7·70	2·26	4·52	8·60
Third lift, 10 to 15 ft.	0·43	0·86	7·40	0·58	1·16	9·60	2·47	4·94	10·80
Fourth lift, 15 to 20 ft.	0·47	0·94	9·00	0·63	1·26	11·50	2·67	5·34	13·00

EXCAVATE SHAFTS AND BASEMENTS BY HAND IN DRY GROUND AND HOIST BY JACK ROLL OR HAND WINCH

Note.—(1) The labour hours shown are those taken to excavate and hoist to the surface per cu. yd. exclusive of timbering.

(2) The hours shown at the various depths are applicable to the whole volume of excavation from ground level to the depths shown.

(3) For timbering shafts and basements, see pp. 182 and 183.

(4) For refilling and ramming, see p. 183.

(5) For loading and transporting the excavated material to tip, the estimator is referred to pp. 155–7.

(6) For excavating shafts and basements by hand and staging the excavated material to the surface, see p. 179.

(7) For excavating shafts and basements by hand and hoisting the excavated material by power-driven crane, see next table.

(8) The rock referred to is rock with many fissures and of a stratified nature.

Depth of excavation in feet	*Nature of ground and labour hours excavating and hoisting by jack roll or hand winch. Per cu. yd.*						
	Firm sand	*Loamy soil, soft or sandy clay or marl*	*Stiff clay*	*Gravel or compact ground requiring picking*	*Chalk*	*Soft stratified fissured rock*	*Hard stratified fissured rock*
0 to 10	3·80	4·20	4·60	5·20	6·60	8·32	11·52
0 to 20	4·75	5·25	5·50	6·25	8·25	10·40	14·40
0 to 30	5·70	6·30	6·90	7·80	9·90	12·48	17·28
0 to 40	6·66	7·35	8·05	9·10	11·55	14·56	20·16
0 to 50	7·60	8·40	9·20	10·40	13·20	16·64	23·04

EXCAVATE SHAFTS AND BASEMENTS BY HAND IN DRY GROUND AND HOIST BY POWER-DRIVEN CRANE

Note.—(1) The crane and labour hours shown are those taken to excavate and hoist to the surface per per cu. yd., exclusive of timbering.

(2) The data shown are based on 4 No. men excavating. If the area of the excavation is such that only two men can excavate, the crane and the banksman hours per cu. yd. are twice those shown, the labour hours remaining the same.

(3) The crane and labour hours shown at the various depths are applicable to the whole volume of excavation from ground level to the depths shown.

(4) For timbering shafts and basements, see pp. 182 and 183.

(5) For refilling and ramming, see p. 183.

(6) For loading and transporting the excavated material to tip, the estimator is referred to Section Thirteen, "Excavator Above Ground", pp. 155–7.

(7) For excavating shafts and basements by hand and staging to the surface, see p. 179.

(8) For excavating shafts and basements by hand and hoisting by jack roll or hand winch, see p. 180.

(9) The rock referred to is rock with many fissures and of a stratified nature.

Depth of excavation in feet	*Nature of ground and crane and labour hours excavating and hoisting by power-driven crane. Per cu. yd.*																				
	Firm sand			*Loamy soil, soft or sandy clay or marl*			*Stiff clay*			*Gravel or compact ground requiring picking*			*Chalk*			*Soft stratified fissured rock*			*Hard stratified fissured rock*		
	Crane hours	*Banksman hours*	*Labour hours*	*Crane hours*	*Banksman hours*	*Labour hours*	*Crane hours*	*Banksman hours*	*Labour hours*	*Crane hours*	*Banksman hours*	*Labour hours*	*Crane hours*	*Banksman hours*	*Labour hours*	*Crane hours*	*Banksman hours*	*Labour hours*	*Crane hours*	*Banksman hours*	*Labour hours*
0 to 10 ft.	0·45	0·45	1·80	0·53	0·53	2·12	0·58	0·58	2·32	0·65	0·65	2·60	0·83	0·83	3·32	1·30	1·30	5·20	1·80	1·80	7·20
0 to 20 ft.	0·52	0·52	2·08	0·61	0·61	2·44	0·66	0·66	2·64	0·75	0·75	3·00	0·95	0·95	3·80	1·50	1·50	6·00	2·07	2·07	8·28
0 to 30 ft.	0·59	0·59	2·36	0·69	0·69	2·76	0·75	0·75	3·00	0·85	0·85	3·40	1·07	1·07	4·28	1·70	1·70	6·80	2·34	2·34	9·36
0 to 40 ft.	0·65	0·65	2·60	0·77	0·77	3·08	0·84	0·84	3·36	0·95	0·95	3·80	1·20	1·20	4·80	1·90	1·90	7·60	2·61	2·61	10·44
0 to 50 ft.	0·72	0·72	2·88	0·85	0·85	3·40	0·93	0·93	3·72	1·05	1·05	4·20	1·33	1·33	5·32	2·10	2·10	8·40	2·88	2·88	11·52

TIMBERING SHAFTS AND BASEMENTS IN DRY GROUND

Note.—(1) The timberman and labourer hours shown are those taken to timber the excavation per sq. yd. of face.

(2) The data shown allow for both fixing and removing the timber.

(3) The data shown for shafts are applicable to excavations up to 20 sq. yds. in area, and that for basements for areas in excess of this.

(4) The total cu. ft. of timber required to timber the excavations per sq. yd. of face is as follows:

	Shafts	*Basements*
Firm ground	1·00 cu. ft. per sq. yd.	1·30 cu. ft. per sq. yd.
Moderately firm ground ..	2·00 cu. ft. per sq. yd.	2·70 cu. ft. per sq. yd.
Loose ground	3·40 cu. ft. per sq. yd.	4·50 cu. ft. per sq. yd.

(5) For purposes of estimating, allow for "use and waste" of timber as follows:

Shafts	12 No. uses.
Basements	15 No. uses.

(6) The tables for timbering shafts and basements are shown in two forms, viz.:

(*a*) timbering in lifts of 5 ft., the hours shown for the various lifts being applicable to the whole area of timber in the lift to which they refer;

(*b*) timbering at depths ranging from 0 to 50 ft. deep, the hours shown at the various depths being applicable to the whole area of timber from ground level to the depths shown.

TIMBERING SHAFTS IN DRY GROUND IN 5 FT. LIFTS

Depth of excavation in feet	*Nature of ground and timberman and labourer hours timbering shafts in 5 ft. lifts. Per sq. yd.*					
	Firm ground		*Moderately firm ground*		*Loose ground*	
	Timberman hours	*Labour hours*	*Timberman hours*	*Labour hours*	*Timberman hours*	*Labour hours*
First lift, 0 to 5 ft.	0·08	0·08	0·30	0·30	0·60	0·60
Second lift, 5 to 10 ft. ..	0·10	0·10	0·40	0·40	0·80	0·80
Third lift, 10 to 15 ft. ..	0·13	0·13	0·50	0·50	1·00	1·00
Fourth lift, 15 to 20 ft. ..	0·15	0·15	0·60	0·60	1·20	1·20

TIMBERING SHAFTS IN DRY GROUND AT DEPTHS RANGING FROM 0 TO 50 FEET DEEP

Depth of excavation in feet	*Nature of ground and timberman and labourer hours timbering shafts, per sq yd.*					
	Firm ground		*Moderately firm ground*		*Loose ground*	
	Timberman hours	*Labour hours*	*Timberman hours*	*Labour hours*	*Timberman hours*	*Labour hours*
0 to 10	0·09	0·09	0·35	0·35	0·70	0·70
0 to 20	0·11	0·11	0·44	0·44	0·88	0·88
0 to 30	0·14	0·14	0·53	0·53	1·05	1·05
0 to 40	0·16	0·16	0·62	0·62	1·23	1·23
0 to 50	0·18	0·18	0·70	0·70	1·40	1·40

Excavating Tunnels

In excavating tunnels the following operations have to be carried out:

1. The miner has to excavate the ground at the tunnel face and, if the nature of the ground necessitates timbering, carry out the timbering of the tunnel as the work proceeds.
2. The excavated material has to be transported from the tunnel face through the tunnel to the bottom of the shaft.
3. The excavated material has to be hoisted to the surface.

TIMBERING BASEMENTS IN DRY GROUND IN 5 FT. LIFTS

Depth of excavation in feet	*Nature of ground and timberman and labourer hours timbering basements in 5 ft. lifts. Per sq. yd.*					
	Firm ground		*Moderately firm ground*		*Loose ground*	
	Timberman hours	*Labour hours*	*Timberman hours*	*Labour hours*	*Timberman hours*	*Labour hours*
First lift, 0 to 5 ft.	0·19	0·19	0·75	0·75	1·50	1·50
Second lift, 5 to 10 ft. ..	0·25	0·25	1·00	1·00	2·00	2·00
Third lift, 10 to 15 ft. ..	0·31	0·31	1·25	1·25	2·50	2·50
Fourth lift, 15 to 20 ft. ..	0·38	0·38	1·50	1·50	3·00	3·00

TIMBERING BASEMENTS IN DRY GROUND AT DEPTHS RANGING FROM 0 TO 50 FEET DEEP

Depth of excavation in feet	*Nature of ground and timberman and labourer hours timbering basements. Per sq. yd.*					
	Firm ground		*Moderately firm ground*		*Loose ground*	
	Timberman hours	*Labour hours*	*Timberman hours*	*Labour hours*	*Timberman hours*	*Labour hours*
0 to 10	0·22	0·22	0·87	0·87	1·75	1·75
0 to 20	0·28	0·28	1·09	1·09	2·19	2·19
0 to 30	0·33	0·33	1·20	1·20	2·63	2·63
0 to 40	0·39	0·39	1·47	1·47	3·07	3·07
0 to 50	0·44	0·44	1·74	1·74	3·50	3·50

REFILLING AND RAMMING EXCAVATIONS

Note.—The data shown are also applicable to trenches.

Nature of ground	*Labour hours refilling and ramming wholly by hand. Per cu. yd.*	*Refilling and ramming, using rammers of the Pegson type. Per cu. yd.*	
		Rammer and man hours. Per cu. yd.	*Labour filling hours. Per cu. yd.*
Firm sand	0·90	0·16	0·48
Loamy soil, sandy clay, soft clay or marl	1·10	0·20	0·60
Stiff clay	1·20	0·22	0·66
Gravel	1·00	0·18	0·54
Chalk	1·10	0·20	0·60
Broken rock	1·10	0·20	0·60

Regarding the material excavated from a tunnel, this may have to be partly refilled and rammed in the tunnel, the remainder being disposed of by loading and hauling it to tip, or spreading and levelling it adjacent to the shaft if conditions permit, or, alternatively, none may have to be refilled and rammed, the whole being disposed of in one or other of the ways mentioned. In estimating the cost of the excavation, therefore, the estimator must take the above into consideration and "build up" the cost accordingly.

In excavating tunnels it is usual to have two tunnels emanating from one shaft, thus the excavated material from two tunnels is hoisted by one jack roll or one power-driven crane, set at the head of the shaft. In this connection it should be noted that the area of the tunnel face and the number of miners it is possible to have excavating governs the crane hours per cu. yd. of excavation, for if the area is such that two miners can work in each tunnel the crane hours per cu. yd. of excavation are only half of what they would be were only one miner in each.

The length of the tunnel from the shaft is variable. The data shown in the tables for estimating purposes refer to tunnels whose length from the shaft does not exceed 50 ft. For estimating the cost of tunnel work whose length is in excess of this, a table of multipliers is shown for use in conjunction with the data shown in the main estimating tables. The data shown cover tunnels ranging in depth from 0 to 50 ft. below the ground.

Timbering Tunnels

For purposes of estimating the cost of timbering tunnels, data are shown for carrying this out in various classes of ground. The data show the timberman and labourer hours per sq. yd. in fixing the timber only, the area of the walls and roof being measured. In the floor of a tunnel the timber fixed consists of footblocks and stretchers only, and the data shown take this into consideration.

The amount of timber required per sq. yd. is also stated, as is the number of uses to allow for "use and waste".

In tunnel work, in general, it is wise to err on the side of safety in assessing the amount of timber recoverable. In the case of most grounds, apart from firm chalk or rock, a proportion of the timber has to be left in, and this loss of timber must be allowed for.

The Tables shown from which to Estimate the Cost of Tunnel Work

The tables shown for estimating the cost of tunnel work are based on one shaft servicing two tunnels emanating from it with one miner in each tunnel.

Note.—(1) If the area of the tunnel is such that two miners can excavate in each tunnel and a crane is used to hoist the excavated material, the crane and banksman's hours are then one-half of those shown, the miner and labourer hours remaining the same.

(2) The data shown for excavating and hoisting does not allow for spreading and levelling if the excavation is disposed of around the shaft, or loading and hauling it to tip. The estimator is referred to Section Thirteen, "Excavator Above Ground", where suitable data may be found for these operations.

The tables shown for estimating purposes are as follows:

1. Excavate tunnels and hoist to the surface by jack roll or hand winch.
2. Excavate tunnels and hoist to the surface by power-driven crane.
3. Timber tunnels.
4. Refill and ram tunnels.
5. Table of multipliers for use with the plant and labour hours shown for tunnels whose length from the shaft exceeds 50 ft.

In order that the estimator may be conversant with the use of the tables a typical example is shown of the "build up" of the cost of tunnel excavation carried out in soft clay.

Example.—Estimate the cost per lin. yd. of excavating and timbering a tunnel in soft clay, the excavated material being hoisted by a power-driven crane. The following are the particulars appertaining to the work:

(*a*) The tunnel is 30 ft. below ground level, and the length driven from the shaft is 100 lin. ft.
(*b*) The dimensions of the tunnel excavation are 6 ft. high × 3 ft. wide.
(*c*) One miner excavates at each tunnel face.

For purposes of this example the following rates are assumed:

Hire rate or working cost of the crane, including driver, fuel and oil = 6/- per hour
Miner's rate .. .. = 2/6 "
Banksman's rate .. .. = 2/2 "
Labourer's rate .. .. = 2/- "
Initial cost of the timber used in timbering the tunnel .. .. .. = 5/- per cu. ft.

Excavating the Tunnel and Hoisting to the Surface per lin. yd.

Referring to the table shown on p. 188, data are shown for excavating and hoisting in tunnels in soft clay for tunnels whose length is not in excess of 50 ft. The hours shown multiplied by the prevailing rates give the estimated cost per cu. yd., thus:

Crane .. .. 1·31 hrs. at 6/- per hr. = 94·32 pence per cu. yd.
Banksman .. .. .. 1·31 hrs. at 2/2 per hr. = 34·06 ,, ,, ,,
Miner .. .. 2·62 hrs. at 2/6 per hr. = 78·60 ,, ,, ,,
Labourer .. .. .. 2·62 hrs. at 2/- per hr. = 62·88 ,, ,, ,,
∴ Cost of excavating and hoisting .. .. .. =269·86 ,, ,, ,,

This 269·86 pence per cu. yd. refers to tunnels 30 ft. below the ground whose length from the shaft is not in excess of 50 ft. Referring to the table of multipliers shown on p. 190, the multiplier to use for tunnels 100 ft. in length from the shaft is 1·10.

Therefore the cost of the excavation in this case of this example is:

1·10 × 269·86 pence per cu. yd. = 296·84 pence per cu. yd.

and since the volume of excavation in the tunnel per lin. yd. is 6 × 3 × 3 ft. = 2 cu. yds.

The cost of excavating the tunnel per lin. yd. = 2 cu. yds. × 296·86 pence
= 593·72 pence per lin. yd.

Timbering the Tunnel per lin. yd.

Referring to the table shown on p. 190, the following data for the timbering of tunnels 30 ft. deep below ground in moderately firm ground are shown:

1. Miner and labourer hours timbering tunnel per sq. yd. = 0·50 hr. each.
2. Timber required per sq. yd. = 1·60 cu. ft.
3. Number of uses of timber to allow for "use and waste" = 3 No.

Note.—Regarding (3), if it is definitely specified that all timber has to be left in, the number of uses to allow would be 1 No. In allowing 3 No. uses it is assessed that two-thirds of the timber can be removed.

Since the initial cost of the timber is 5/- per cu. ft. and the amount required per sq. yd. is 1·60 cu. ft., the number of uses to allow for "use and waste" being assessed at 3 No.

The allowance for "use and waste" per sq. yd. is:

$$\frac{5/-}{3\text{ No. uses}} \times 1{\cdot}60\text{ cu. ft.}$$
$$= 32{\cdot}00\text{ pence per sq. yd.}$$

The cost of fixing and placing the timber per sq. yd. in tunnels whose length does not exceed 50 ft. from the shaft then is:

Miner .. .. 0·50 hr. at 2/6 per hr. = 15·00 pence per sq. yd.
Labourer .. .. .. 0·50 hr. at 2/- per hr. = 12·00 ,, ,, ,,
∴ Labour cost of fixing only .. .. .. = 27·00 ,, ,, ,,

In the case of this example the tunnel is 100 ft. in length from the shaft and the multiplier 1·10 is used as before.

∴ The labour cost of timbering per sq. yd. is:

1·10 × 27·00 = 29·70 pence per sq. yd.

The total cost of timbering per sq. yd., then, is the sum of the labour cost, plus the allowance for the "use and waste" of the timber.

∴ Total cost of timbering per sq. yd. is:

Labour cost .. .. 29·70 pence per sq. yd.
Allow for "use and waste" .. .. 32·00 ,, ,, ,,
Total cost .. .. 61·70 ,, ,, ,,

The area of timbering to be carried out per lin. yd. of tunnel is the perimeter of the two side walls and roof in feet multiplied by 3 lin. ft. The area to be timbered per lin. yd. of tunnel, therefore, is:

$$\frac{3\,(6\text{ ft.} + 6\text{ ft.} + 3\text{ ft.})}{9}$$

= 5 sq. yds.

∴ The cost of timbering the tunnel per lin. yd. = 5 sq. yds. × 61·70 pence
= 308·50 pence per lin. yd.

The total cost of excavating and timbering the tunnel per lin. yd. then is:

Excavating and hoisting = 593·72 pence per lin. yd.
Timbering .. .. 308·50 " " "
Total cost .. = 902·22 " " "
Say 75/2d. per lin. yd.

The cost of the timbered excavation per cu. yd. is obtained by dividing the above total cost per lin. yd. by the cu. yds. of excavation in the tunnel per lin. yd.

$$\frac{902{\cdot}22 \text{ pence}}{2 \text{ cu. yds.}}$$

= 451·11 pence per cu. yd.
Say 37/7d. per cu. yd.

Note.—In the example shown no allowance has been made for loading and transporting the excavated material to tip. It is uneconomical to keep transporting plant waiting while the crane loads direct, as the excavation rate is low. For purposes of estimating, the loading and transporting cost of the excavated material should be treated as a separate operation. The estimator is referred to Section Thirteen, "Excavator Above Ground", where suitable data are shown for this, as are data for spreading and levelling the excavated material.

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FIG. 23.—PNEUMATIC PICK HAMMER AND ROCK DRILLS TRIMMING SIDES OF TUNNEL

EXCAVATE TUNNELS AND HOIST BY JACK ROLL OR HAND WINCH

Note.—(1) The miner and labour hours shown are those taken to excavate, haul through to the shaft, and hoist to the surface per cu. yd., exclusive of timbering.

(2) The data shown are based on one shaft servicing two tunnels emanating from it, with one miner excavating in each tunnel.

(3) The data shown are applicable to tunnels whose length from the shaft is not in excess of 50 ft. For tunnels in excess of this length use the table of multipliers shown on p. 190.

(4) For timbering tunnels, see p. 190.

(5) For refilling and ramming tunnels, see p. 190.

(6) For loading and transporting the excavated material the estimator is referred to Section Thirteen, "Excavator Above Ground", pp. 155–7.

(7) For excavating tunnels and hoisting by power-driven crane, see p. 188.

(8) For excavating headings, see p. 189.

(9) The rock referred to is rock with many fissures and of a stratified nature.

Depth of tunnel below ground in feet	*Nature of ground and miner and labourer hours excavating tunnels, hauling to shaft and hoisting by jack roll or hand winch per cu. yd. in tunnels whose length from the shaft is not in excess of 50 ft.*													
	Firm sand		*Loamy soil, soft or sandy clay or marl*		*Stiff clay*		*Gravel or compact ground requiring picking*		*Chalk*		*Soft stratified fissured rock*		*Hard stratified fissured rock*	
	Miner hours	*Labour hours*	*Miner hours*	*Labour hours*	*Miner hours*	*Labour hours*	*Miner hours*	*Labour hours*	*Miner hours*	*Labour hours*	*Miner hours*	*Labour hours*	*Miner hours*	*Labour hours*
0 to 20	2·30	6·90	2·50	7·50	2·80	8·40	3·10	9·30	4·00	10·00	6·20	12·40	8·60	13·40
0 to 30	2·53	7·59	2·75	8·25	3·08	9·24	3·41	10·23	4·40	11·00	6·82	13·64	9·46	14·74
0 to 40	2·76	8·28	3·00	9·00	3·36	10·08	3·72	11·16	4·80	12·00	7·44	14·88	10·32	16·08
0 to 50	3·00	9·00	3·25	9·75	3·64	10·92	4·03	12·09	5·20	13·00	8·06	16·12	11·18	17·42

EXCAVATE TUNNELS AND HOIST BY POWER-DRIVEN CRANE

Note.—(1) The crane, banksman, miner and labourer hours shown are those taken to excavate, haul through to the shaft, and hoist to the surface per cu. yd., exclusive of timbering.

(2) The data shown are based on one shaft servicing two tunnels emanating from it, with one miner in each tunnel. If the area of the tunnel is such that two miners can excavate in each tunnel, the crane and banksman hours per cu. yd. are one-half of those shown, the miner and labour hours remaining the same.

(3) The data shown are applicable to tunnels whose length from the shaft is not in excess of 50 ft. For tunnels in excess of this length use the table of multipliers shown on p. 190.

(4) For timbering tunnels, see p. 190.

(5) For refilling and ramming tunnels, see p. 190.

(6) For loading and transporting the excavated material to tip, the estimator is referred to Section Thirteen, "Excavator Above Ground", pp. 155–7.

(7) For excavating headings, see p. 189.

(8) The rock referred to is rock with many fissures and of a stratified nature.

Depth of tunnel below ground in feet	*Nature of ground and crane, banksman, miner and labourer hours excavating tunnels, hauling to the shaft, and hoisting by power-driven crane per cu. yd. in tunnels whose length from the shaft is not in excess of 50 ft.*																											
	Firm sand				*Loamy soil, soft or sandy clay or marl*				*Stiff clay*				*Gravel or compact ground requiring picking*				*Chalk*				*Soft stratified fissured rock*				*Hard stratified fissured rock*			
	Crane hours	*Banksman hours*	*Miner hours*	*Labourer hours*	*Crane hours*	*Banksman hours*	*Miner hours*	*Labourer hours*	*Crane hours*	*Banksman hours*	*Miner hours*	*Labourer hours*	*Crane hours*	*Banksman hours*	*Miner hours*	*Labourer hours*	*Crane hours*	*Banksman hours*	*Miner hours*	*Labourer hours*	*Crane hours*	*Banksman hours*	*Miner hours*	*Labourer hours*	*Crane hours*	*Banksman hours*	*Miner hours*	*Labourer hours*
0 to 20	1·15	1·15	2·30	2·30	1·25	1·25	2·50	2·50	1·40	1·40	2·80	2·80	1·55	1·55	3·10	3·10	2·00	2·00	4·00	4·00	3·10	3·10	6·20	6·20	4·30	4·30	8·60	8·60
0 to 30	1·20	1·20	2·40	2·40	1·31	1·31	2·62	2·62	1·47	1·47	2·94	2·94	1·63	1·63	3·26	3·26	2·10	2·10	4·20	4·20	3·25	3·25	6·50	6·50	4·52	4·52	9·04	9·04
0 to 40	1·30	1·30	2·60	2·60	1·38	1·38	2·76	2·76	1·54	1·54	3·08	3·08	1·71	1·71	3·42	3·42	2·20	2·20	4·40	4·40	3·40	3·40	6·80	6·80	4·78	4·78	9·56	9·56
0 to 50	1·40	1·40	2·80	2·80	1·45	1·45	2·90	2·90	1·61	1·61	3·22	3·22	1·80	1·80	3·60	3·60	2·30	2·30	4·60	4·60	3·55	3·55	7·10	7·10	5·00	5·00	10·00	10·00

Excavate Headings

In excavating "headings", one heading only is driven from the shaft or face, and in such a case it is not usual or economical to use a power-driven crane to hoist the excavated material to the surface. In such cases the hoisting is generally carried out by hand by means of a jack roll or hand winch, and the data shown are based on this method of hoisting.

Note.—(1) The miner and labour hours shown are those taken to excavate, haul through the heading, and hoist to the surface, exclusive of timbering. For timbering headings, see p. 190.

(2) For refilling and ramming headings, see p. 190.

(3) The data shown are applicable to headings whose length is not in excess of 50 ft. For headings in excess of this, the table of multipliers shown on p. 190 may be used.

(4) For loading and transporting the excavated material the estimator is referred to Section Thirteen, "Excavator Above Ground", pp. 155–7.

(5) The rock referred to is rock with many fissures and of a stratified nature.

Depth of heading below ground in feet	*Nature of ground and miner and labour hours excavating headings, hauling to the face, and hoisting by jackroll or hand winch, per cu. yd. in headings whose length is not in excess of 50 ft.*													
	Firm sand		*Loamy soil, soft or sandy clay or marl*		*Stiff clay*		*Gravel or compact ground requiring picking*		*Chalk*		*Soft stratified fissured rock*		*Hard stratified fissured rock*	
	Miner hours	*Labour hours*	*Miner hours*	*Labour hours*	*Miner hours*	*Labour hours*	*Miner hours*	*Labour hours*	*Miner hours*	*Labour hours*	*Miner hours*	*Labour hours*	*Miner hours*	*Labour hours*
0 to 20	2·30	9·20	2·50	10·00	2·80	11·20	3·10	12·40	4·00	13·33	6·20	16·50	8·60	17·88
0 to 30	2·53	10·12	2·75	11·00	3·08	12·32	3·41	13·64	4·40	14·66	6·82	18·14	9·46	19·68
0 to 40	2·76	11·04	3·00	12·00	3·36	13·44	3·72	14·88	4·80	16·00	7·44	19·80	10·32	21·46
0 to 50	3·00	12·00	3·25	13·00	3·64	14·56	4·03	16·12	5·20	17·33	8·06	21·44	11·18	23·25

TIMBERING TUNNELS AND HEADINGS

Note.—(1) The timberman and labourer hours shown are those taken to timber tunnels or headings per sq. yd., the faces measured being the two side walls and the roof.

(2) The data shown are applicable to tunnels or headings whose length from the shaft is not in excess of 50 ft. For tunnels or headings in excess of this length use the table of multipliers shown below.

(3) The amount of timber required to timber the excavation per sq. yd. of face is as follows:

Firm ground	0·80 cu. ft. per sq. yd.
Moderately firm ground ..	1·60 cu. ft. per sq. yd.
Loose ground	3·00 cu. ft. per sq. yd.

For purposes of estimating allow for "use and waste" of timber as follows:

Firm ground	5 No. uses.
Moderately firm ground ..	3 No. uses.
Loose ground	1 No. use, i.e. all the timber is left in.

Depth of tunnel or heading below ground in feet	*Miner and labour hours timbering tunnels or headings. Per sq. yd.*					
	Firm ground		*Moderately firm ground*		*Loose ground*	
	Miner hours	*Lab. hours*	*Miner hours*	*Lab. hours*	*Miner hours*	*Lab. hours*
0 to 20	0·15	0·15	0·45	0·45	0·90	0·90
0 to 30	0·16	0·16	0·50	0·50	1·00	1·00
0 to 40	0·18	0·18	0·55	0·55	1·10	1·10
0 to 50	0·20	0·20	0·60	0·60	1·20	1·20

REFILL AND RAM TUNNELS AND HEADINGS

Note.—The data shown are for refilling and ramming tunnels or headings whose length is not in excess of 50 ft. from the shaft. For tunnels or headings in excess of this length use the table of multipliers shown below.

Nature of ground	*Method of refilling and ramming, and plant and labour hours. Per cu. yd.*		
	By hand	*By power-driven crane and skip*	
	Labour hours	*Crane hours*	*Labour hours*
Sand	5·40	0·50	3·50
Loamy soil, soft or sandy clay or marl	5·70	0·55	3·85
Stiff clay	7·00	0·65	4·55
Gravel	5·60	0·53	3·71
Chalk or broken rock	6·50	0·60	4·20

TABLE OF MULTIPLIERS FOR USE WITH THE TABLES SHOWN FOR EXCAVATING, TIMBERING AND REFILLING AND RAMMING TUNNELS AND HEADINGS WHERE THE LENGTH OF TUNNEL OR HEADING FROM THE SHAFT IS IN EXCESS OF 50 FEET

Length of tunnel from shaft in feet	*Plant, miner and labour hour multipliers*
0 to 50	1·00
0 to 100	1·10
0 to 150	1·30
0 to 200	1·60

CUBIC YARDS OF EXCAVATION IN TRENCHES OF VARYING WIDTHS PER LIN. YARD

Depth of trench in feet	*Width of trench in feet and inches and cu. yds. per lin. yd.*										
	1–6	1–9	2–0	2–3	2–6	2–9	3–0	3–3	3–6	3–9	4–0
1	0·17	0·20	0·22	0·25	0·28	0·31	0·34	0·37	0·39	0·41	0·44
2	0·33	0·39	0·44	0·50	0·55	0·61	0·67	0·74	0·78	0·83	0·88
3	0·50	0·58	0·66	0·75	0·83	0·92	1·00	1·10	1·17	1·24	1·33
4	0·68	0·78	0·88	1·00	1·11	1·22	1·33	1·46	1·55	1·66	1·77
5	0·83	0·98	1·11	1·25	1·39	1·53	1·66	1·82	1·94	2·07	2·23
6	—	1·18	1·33	1·50	1·66	1·83	2·00	2·18	2·32	2·49	2·67
7	—	—	1·55	1·75	1·94	2·14	2·33	2·54	2·71	2·90	3·12
8	—	—	—	2·00	2·22	2·45	2·66	2·90	3·10	3·31	3·56
9	—	—	—	2·25	2·50	2·75	3·00	3·26	3·44	3·73	4·00
10	—	—	—	—	2·77	3·06	3·33	3·62	3·86	4·15	4·44
11	—	—	—	—	3·05	3·37	3·66	3·98	4·28	4·56	4·88
12	—	—	—	—	3·33	3·67	4·00	4·34	4·67	4·98	5·32

TIMBER, LINEAL FEET PER STANDARD

1 standard timber .. .. = 165 cu. ft.
1 „ 9×3 in. walings .. .. = 882 lin. ft.
1 „ 10×4 in. „ .. .. = 598 „
1 „ 12×6 in. „ .. .. = 330 „
1 „ 4×4 struts .. .. .. = 1,500 „
1 „ 6×6 in. „ .. .. .. = 660 „
1 „ 7×2 in. runners .. .. = 1,833 „
1 „ 8×1½ poling boards .. .. = 1,990 „
1 „ 7×1½ „ „ .. .. = 2,260 „
1 „ 6×1½ „ „ .. .. = 2,660 „

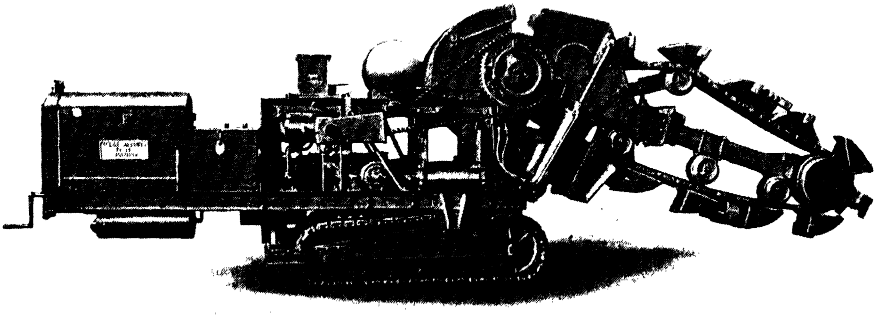

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FIG. 32.—TRENCH EXCAVATOR OF ENDLESS BUCKET TYPE, PARTICULARLY USEFUL FOR CUTTING TRENCHES 12 IN. TO 18 IN. WIDE AND UP TO 6 FT. DEEP

PART TWO

EXCAVATOR BELOW GROUND—WET

In estimating the cost of excavation in water-bearing ground experience proves invaluable, for the experienced estimator forms his opinion as to how much water is likely to be encountered and any other attendant difficulties on past experience of similar works and grounds.

The water-bearing grounds most commonly encountered are:

1. Gravel and water,
2. Sand and water,
3. Chalk and water,

the water content being variable in each case.

The cost of excavation varies considerably in different classes of water-bearing ground. In this connection the estimator should note that the output per man per hour excavating in wet ground is considerably less than in dry ground of a similar kind and the estimation of the cost of the excavation per cubic yard is not simply a matter of adding the pumping cost per cubic yard to dry ground excavation rates.

The correct assessment of the prevailing site conditions and the quantity of water which will have to be pumped in gallons per minute is essential if a "sound" estimate is to be produced; attention to the following points will assist the estimator to achieve this object:

1. Take note of the nature of the ground, i.e. whether gravel, sand or chalk.
2. Examine, if possible, trial holes taken out over the site of the excavation and the depth below ground at which water is encountered.
3. Study the lie of the land, i.e. whether low lying, adjacent to rivers, canals, lakes, sea, etc.: and in the latter case whether the sub-soil water is influenced by the tides.
4. Examine the beds of ditches, rivers, etc. adjoining or passing through the site. Very often information of a valuable nature can be obtained from such an inspection, e.g. a river bed may show a pure gravel or sand bottom.
5. Discuss the ground conditions with those who are in a position to know them, such as local surveyors and engineers.

From the estimator's point of view it is good policy, where much water has to be dealt with, to err "on the side of safety", as it is a fact that such work usually commands a good price on account of the attendant risks.

Sumps and sub drains

In very wet ground it is common practice to sink sumps clear of the line of the main excavation, to a level below that of the main work. Pumping plant of suitable capacity is then placed in position in these sumps to deal with the water in the main excavation. This is done by laying sub drain pipes consisting of stoneware pipes surrounded with shingle or other clean medium in the bottom of the main excavation and leading these to the sump. The data shown for shaft sinking in the various water-bearing grounds is applicable also to sump work and may be used for this purpose.

Timbering in wet ground

The cost of timbering in wet ground varies both with the depth and the water content. In the tables shown for estimating purposes the timberman and labourer hours are shown for timbering trenches per lineal yard of trench, both sides of the trench being allowed for in the hours shown, and per square yard of face for excavations of the shaft and basement type. The amount of timber required and the number of uses to allow for "use and waste" are also given.

In estimating the cost of excavating and timbering in water-bearing ground, the estimator must assess and come to a decision on the following:

1. The nature of the ground.
2. The average amount of water which will have to be dealt with throughout the depth of the excavation from ground level to the lowest point, in gallons per minute.
3. The most suitable type and size of pump or pumps to use on the work.

Having come to a decision on these points the estimate of the cost is then "built up".

Tables for use in estimating

The tables shown for estimating purposes are as follows:

1. Excavate, refill and ram trenches per cubic yard in water-bearing ground of various kinds and of different water content.
2. Excavate shafts and basements per cubic yard in water-bearing ground of various kinds and of different water content.
3. Timbering trenches per lineal yard in water-bearing ground of different water content.
4. Timbering shafts and basements per square yard in water-bearing ground of different water content.

In connection with these tables the following points should be noted:

(*a*) The data shown for excavating are shown in lifts of 5 feet, the hours shown being applicable to the volume of excavation in the lift to which they refer.

(*b*) The data shown for timbering shafts and basements are per square yard of face and are shown in lifts of 5 feet, the hours shown being applicable to the area of timber in the lift to which they refer. The amount of timber required per square yard and the number of uses to allow for "use and waste" are given.

(*c*) The data cover various classes of ground of different water content. To estimate the cost of a specific excavation the estimator must assess the gallons to be pumped per minute throughout the excavation as an average for the whole of its depth, and use the data shown corresponding to this in building up the estimate.

(*d*) The working cost per hour of pumps of various sizes can be obtained by referring to Section Twenty, page 231, or, if it is intended to hire pumping equipment, by obtaining hire rates from a recognised plant-hiring firm dealing in this class of plant.

Note.—1. In some cases no actual pump driver is required, this applying in particular to grounds of low water content. The pump is, under such circumstances, serviced by one of the gang and in ascertaining the pump hire rate per hour for estimating purposes the pump driver may then be allowed for on a part-time basis.

2. In excavating trenches in wet ground it is usual to open up only a limited length of trench at one time, i.e. the trench is excavated in comparatively short lengths; the permanent work such as pipelaying etc. is then completed and the trench refilled before further excavation is carried out. If necessary a sub drain may be laid in the trench as the work proceeds in order to handle the water back to the sumps as further trench work is excavated. By adopting this method of working the water to be cleared by the pumping plant is kept within reasonable limits and the work is carried out with greater ease than if a long length of trench is tackled at one time. As an example of this, in excavating a trench of fair depth in running sand four 15 ft. frames, i.e. a trench 60 ft. long, might be opened up at one time, all work being completed in this 60 ft. length and the trench refilled before proceeding to take out the next four frames.
The data shown for work in wet ground is based on carrying out the work on these lines, the amount of ground opened at one time varying with the water content, the nature of the ground and the depth of the excavation.

OUTPUT OF DIAPHRAGM PUMPS

Dia. of suction in inches	*Description*	*Engine h.p.*	*Output in gallons per minute*			
			5 ft. *lift*	10 ft. *lift*	15 ft. *lift*	20 ft. *lift*
3	Single diaphragm spout delivery . .	1½	75	66	50	35
3	Double ,, ,, ,, ...	1½	150	132	100	70
4	Single ,, ,, ,, ...	2½	110	100	75	50
4	Double ,, ,, ,, ...	2½	220	200	150	100
2	Lift and force type	1½	30	26	20	15
3	,, ,, ,, ...	1½	75	66	50	37
4	,, ,, ,, ...	2½	110	100	75	56
3	Single diaphragm hand pump	—	25	20	16	—

OUTPUT OF CENTRIFUGAL PUMPS

Dia. of suction in in.	*Engine horse power*	*Output in gallons per minute*			
		20 *ft. lift*	30 *ft. lift*	40 *ft. lift*	50 *ft. lift*
2	2½	80	72	60	45
3	5	180	160	130	100
4	7½	320	280	240	180
5	10	540	480	400	300
6	15	720	650	540	400
7	20	1000	900	750	550
8	30	1300	1150	1000	720
9	40	1650	1380	1240	910
10	45	2000	1800	1500	1200
12	50	3000	2700	2250	1650

OUTPUT OF PULSOMETER PUMPS

Dia. of suction in inches	*Output in gallons per minute*			
	20 *ft. lift*	30 *ft. lift*	40 *ft. lift*	50 *ft. lift*
3	80	70	60	45
3½	100	90	75	55
4	160	140	120	90
4½	210	190	160	120
5	340	300	250	190
6	450	400	330	250
7	670	600	500	370

Excavate refill and ram trenches by hand in water-bearing ground.

Note.—(1) The data show the pump and labour hours taken to excavate, refill and ram trenches per cubic yard exclusive of timbering, the excavated material being staged to the surface.

(2) The pump and labour hours shown at the various lifts are applicable to the volume of excavation contained in the lift to which they refer.

(3) In estimating the cost per cubic yard of excavating, refilling, and ramming trenches in water-bearing ground the average gallons of water to be pumped per minute throughout the depth of the trench should be assessed and the pump and labour hours shown under the various lifts corresponding to this assessed amount used to "build up" the estimate.

(4) For timbering trenches in water-bearing grounds, see page 196.

(5) For the Outputs of diaphragm, centrifugal and pulsometer pumps in gallons per minute, see above.

EXCAVATE, REFILL AND RAM TRENCHES IN WATER-BEARING GRAVEL

Estimated gallons of water to be pumped per minute	*Pump and labour hours excavating, refilling and ramming trenches in lifts of 5 ft. per cu. yd.*							
	1st lift 0 to 5 ft.		*2nd lift 5 to 10 ft.*		*3rd lift 10 to 15 ft.*		*4th lift 15 to 20 ft.*	
	Pump hours	*Labour hours*	*Pump hours*	*Labour hours*	*Pump hours*	*Labour hours*	*Pump hours*	*Labour hours*
50	0·17	4·45	0·17	7·30	0·17	8·90	0·17	10·50
100	0·18	4·50	0·18	7·38	0·18	9·00	0·18	10·62
150	0·19	4·55	0·19	7·46	0·19	9·10	0·19	10·74
200	0·20	4·60	0·20	7·54	0·20	9·20	0·20	10·86
300	0·22	4·70	0·22	7·70	0·22	9·40	0·22	11·10
400	0·24	4·80	0·24	7·87	0·24	9·60	0·24	11·33
500	0·26	4·90	0·26	8·04	0·26	9·80	0·26	11·56
600	0·28	5·00	0·28	8·20	0·28	10·00	0·28	11·80
700	0·30	5·10	0·30	8·36	0·30	10·20	0·30	12·04
800	0·32	5·20	0·32	8·53	0·32	10·40	0·32	12·27
900	0·34	5·30	0·34	8·69	0·34	10·60	0·34	12·51
1000	0·36	5·40	0·36	8·86	0·36	10·80	0·36	12·74
1250	0·41	5·65	0·41	9·27	0·41	11·30	0·41	13·33
1500	0·46	5·90	0·46	9·68	0·46	11·80	0·46	13·92
1750	0·51	6·15	0·51	10·08	0·51	12·30	0·51	14·52
2000	0·56	6·40	0·56	10·50	0·56	12·80	0·56	15·10
2250	0·61	6·65	0·61	10·91	0·61	13·30	0·61	15·69
2500	0·66	6·90	0·66	11·32	0·66	13·80	0·66	16·28

EXCAVATE, REFILL AND RAM TRENCHES IN WATER-BEARING SAND

Estimated gallons of water to be pumped per minute	*Pump and labour hours excavating, refilling and ramming trenches in lifts of 5 ft. per cu. yd.*							
	1st lift 0 to 5 ft.		*2nd lift 5 to 10 ft.*		*3rd lift 10 to 15 ft.*		*4th lift 15 to 20 ft.*	
	Pump hours	*Labour hours*	*Pump hours*	*Labour hours*	*Pump hours*	*Labour hours*	*Pump hours*	*Labour hours*
50	0·24	5·93	0·24	10·20	0·24	12·27	0·24	14·34
100	0·25	6·02	0·25	10·35	0·25	12·45	0·25	14·55
150	0·26	6·11	0·26	10·50	0·26	12·64	0·26	14·78
200	0·27	6·20	0·27	10·66	0·27	12·83	0·27	15·00
300	0·30	6·38	0·30	10·97	0·30	13·20	0·30	15·43
400	0·33	6·56	0·33	11·28	0·33	13·57	0·33	15·86
500	0·36	6·74	0·36	11·59	0·36	13·94	0·36	16·29
600	0·39	6·92	0·39	11·90	0·39	14·31	0·39	16·72
700	0·42	7·10	0·42	12·21	0·42	14·68	0·42	17·15
800	0·45	7·28	0·45	12·52	0·45	15·05	0·45	17·58
900	0·48	7·46	0·48	12·83	0·48	15·43	0·48	18·03
1000	0·51	7·64	0·51	13·14	0·51	15·80	0·51	18·46

EXCAVATE, REFILL AND RAM TRENCHES IN WATER-BEARING CHALK

Estimated gallons of water to be pumped per minute	*Pump and labour hours excavating, refilling and ramming trenches in lifts of 5 ft. per cu. yd.*							
	1st lift 0 to 5 ft.		*2nd lift 5 to 10 ft.*		*3rd lift 10 to 15 ft.*		*4th lift 15 to 20 ft.*	
	Pump hours	*Labour hours*	*Pump hours*	*Labour hours*	*Pump hours*	*Labour hours*	*Pump hours*	*Labour hours*
50	0·20	5·00	0·20	8·30	0·20	10·00	0·20	11·70
100	0·21	5·10	0·21	8·46	0·21	10·20	0·21	11·94
150	0·22	5·20	0·22	8·63	0·22	10·40	0·22	12·17
200	0·23	5·30	0·23	8·80	0·23	10·60	0·23	12·40
300	0·26	5·51	0·26	9·15	0·26	11·02	0·26	12·89
400	0·29	5·72	0·29	9·50	0·29	11·44	0·29	13·38
500	0·32	5·94	0·32	9·85	0·32	11·88	0·32	13·91
600	0·35	6·15	0·35	10·20	0·35	12·30	0·35	14·40
700	0·38	6·36	0·38	10·55	0·38	12·72	0·38	14·91
800	0·41	6·57	0·41	10·90	0·41	13·14	0·41	15·38
900	0·44	6·78	0·44	11·25	0·44	13·56	0·44	15·87
1000	0·47	7·00	0·47	11·60	0·47	14·00	0·47	16·40

Timbering trenches in water-bearing ground.

Note.—(1) The timberman and labourer hours shown are those taken to timber the trench per lineal yard of trench, both sides of the trench being allowed for in the hours shown.

(2) The data shown allows for both fixing and removing the timber.

(3) The amount of timber shown is the total cubic feet of timber required to timber the trench per lineal yard both sides of the trench being allowed for. For purposes of estimating allow for "use and waste" 10 No. uses of the timber.

(4) In estimating the cost of timbering per lineal yard of trench in water-bearing ground, the average gallons of water to be pumped per minute throughout the depth of the trench should be assessed and the timberman and labour hours shown at the various depths corresponding to this assessed amount used to "build up" the estimate.

(5) For the outputs of diaphragm, centrifugal and pulsometer pumps in gallons per minute, see page 194.

epth of ench in feet	*Estimated gallons of water to be pumped per minute, cubic feet of timber required and timberman and labour hours timbering trenches per lineal yard of trench*											
	0 *to* 250 *galls. per minute*			250 *to* 750 *galls. per minute*			750 *to* 1500 *galls. per minute*			1500 *to* 2500 *galls. per minute*		
	Timber cu. ft.	*Timb. hours*	*Labour hours*	*Timber cu. ft.*	*Timb. hours*	*Labour hours*	*Timber cu. ft.*	*Timb. hours*	*Labour hours*	*Timber cu. ft.*	*Timb. hours*	*Labour hours*
3	4·00	0·43	0·43	5·00	0·54	0·54	6·00	0·68	0·68	7·00	0·86	0·86
4	5·32	0·60	0·60	6·66	0·75	0·75	8·00	0·95	0·95	9·33	1·20	1·20
5	6·66	0·80	0·80	8·33	1·00	1·00	10·00	1·25	1·25	11·66	1·58	1·58
6	8·00	1·00	1·00	10·00	1·26	1·26	12·00	1·60	1·60	14·00	2·02	2·02
7	9·33	1·22	1·22	11·66	1·54	1·54	14·00	1·94	1·94	16·33	2·45	2·45
8	10·66	1·46	1·46	13·33	1·84	1·84	16·00	2·32	2·32	18·66	2·93	2·93
9	12·00	1·72	1·72	15·00	2·16	2·16	18·00	2·73	2·73	21·00	3·45	3·45
10	13·33	2·00	2·00	16·66	2·50	2·50	20·00	3·15	3·15	23·33	3·98	3·98
11	14·66	2·28	2·28	18·33	2·86	2·86	22·00	3·61	3·61	25·66	4·56	4·56
12	16·00	2·58	2·58	20·00	3·24	3·24	24·00	4·10	4·10	28·00	5·18	5·18
13	17·33	2·90	2·90	21·66	3·64	3·64	26·00	4·60	4·60	30·33	5·81	5·81
14	18·66	3·24	3·24	23·33	4·06	4·06	28·00	5·13	5·13	32·66	6·48	6·48
15	20·00	3·60	3·60	25·00	4·50	4·50	30·00	5·70	5·70	35·00	7·20	7·20
16	21·33	3·97	3·97	26·66	4·96	4·96	32·00	6·27	6·27	37·33	7·92	7·92
17	22·66	4·35	4·35	28·33	5·44	5·44	34·00	6·88	6·88	39·66	8·69	8·69
18	24·00	4·75	4·75	30·00	5·94	5·94	36·00	7·52	7·52	42·00	9·50	9·50
19	25·33	5·17	5·17	31·66	6·46	6·46	38·00	8·17	8·17	44·33	10·32	10·32
20	26·66	5·60	5·60	33·33	7·00	7·00	40·00	8·85	8·85	46·66	11·18	11·18

Excavate shafts and basements by hand in water-bearing ground.

Note.—(1) The data shows the pump and labour hours taken per cubic yard to excavate shafts and basements by hand, the excavated material being staged to the surface, and is exclusive of timbering.

(2) The pump and labour hours shown at the various lifts are applicable to the volume of excavation contained in the lift to which they refer.

(3) In estimating the cost per cubic yard of excavating shafts and basements in water-bearing ground, the average gallons of water to be pumped per minute throughout the depth of the excavation should be assessed and the pump and labour hours shown under the various lifts corresponding to this assessed amount used to "build up" the estimate.

(4) For timbering shafts and basements in water-bearing ground, see page 198.

(5) For the output of diaphragm, centrifugal and pulsometer pumps in gallons per minute, see page 194.

(6) The pump hours shown are based on four men excavating, there being one stage man per stage and one man clearing on top for every two men excavating. The pump hours per cubic yard are inversely proportional to the number of men excavating, so that if the area is such that only two men can excavate, the pump hours shown must be multiplied by $\frac{4}{2}=2$, the labour hours remaining as shown.

EXCAVATE SHAFTS AND BASEMENTS IN WATER BEARING GRAVEL

Estimated gallons of water to be pumped per minute	*Pump and labour hours excavating shafts and basements in lifts of 5 ft. per cu. yd.*							
	1st lift 0 to 5 ft.		*2nd lift 5 to 10 ft.*		*3rd lift 10 to 15 ft.*		*4th lift 15 to 20 ft.*	
	Pump hours	*Labour hours*	*Pump hours*	*Labour hours*	*Pump hours*	*Labour hours*	*Pump hours*	*Labour hours*
50	0·70	4·20	0·70	5·60	0·70	7·00	0·70	8·40
100	0·71	4·26	0·71	5·68	0·71	7·10	0·71	8·52
150	0·72	4·32	0·72	5·76	0·72	7·20	0·72	8·64
200	0·73	4·38	0·73	5·84	0·73	7·30	0·73	8·76
300	0·75	4·50	0·75	6·00	0·75	7·50	0·75	9·00
400	0·77	4·62	0·77	6·16	0·77	7·70	0·77	9·24
500	0·79	4·74	0·79	6·32	0·79	7.90	0·79	9·48
600	0·81	4·86	0·81	6·48	0·81	8·10	0·81	9·72
700	0·83	4·98	0·83	6·64	0·83	8·30	0·83	9·96
800	0·85	5·10	0·85	6·80	0·85	8·50	0·85	10·20
900	0·87	5·22	0·87	6·96	0·87	8·70	0·87	10·44
1000	0·90	5·40	0·90	7·20	0·90	9·00	0·90	10·80
1250	0·95	5·70	0·95	7·60	0·95	9·50	0·95	11·40
1500	1·00	6·00	1·00	8·00	1·00	10·00	1·00	12·00
1750	1·05	6·30	1·05	8·40	1·05	10·50	1·05	12·60
2000	1·10	6·60	1·10	8·80	1·10	11·00	1·10	13·20
2250	1·15	6·90	1·15	9·20	1·15	11·50	1·15	13·80
2500	1·20	7·20	1·20	9·60	1·20	12·00	1·20	14·40

EXCAVATE SHAFTS AND BASEMENTS IN WATER-BEARING SAND

Estimated gallons of water to be pumped per minute	*Pump and labour hours excavating shafts and basements in lifts of 5 ft. per cu. yd.*							
	1st lift 0 to 5 ft.		*2nd lift 5 to 10 ft.*		*3rd lift 10 to 15 ft.*		*4th lift 15 to 20 ft.*	
	Pump hours	*Labour hours*	*Pump hours*	*Labour hours*	*Pump hours*	*Labour hours*	*Pump hours*	*Labour hours*
50	1·00	6·00	1·00	8·00	1·00	10·00	1·00	12·00
100	1·01	6·06	1·01	8·08	1·01	10·10	1·01	12·12
150	1·03	6·18	1·03	8·24	1·03	10·30	1·03	12·36
200	1·06	6·36	1·06	8·48	1·06	10·60	1·06	12·72
300	1·09	6·54	1·09	8·72	1·09	10·90	1·09	13·08
400	1·12	6·72	1·12	8·96	1·12	11·20	1·12	13·44
500	1·15	6·90	1·15	9·20	1·15	11·50	1·15	13·80
600	1·18	7·08	1·18	9·44	1·18	11·80	1·18	14·16
700	1·21	7·26	1·21	9·68	1·21	12·10	1·21	14·52
800	1·24	7·44	1·24	9·92	1·24	12·40	1·24	14·88
900	1·27	7·72	1·27	10·16	1·27	12·70	1·27	15·24
1000	1·30	7·80	1·30	10·40	1·30	13·00	1·30	15.60

EXCAVATE SHAFTS AND BASEMENTS IN WATER-BEARING CHALK

Estimated gallons of water to be pumped per minute	*Pump and labour hours excavating shafts and basements in lifts of 5 ft. per cu. yd.*							
	1st lift, 0 to 5 ft.		*2nd lift, 5 to 10 ft.*		*3rd lift, 10 to 15 ft.*		*4th lift, 15 to 20 ft.*	
	Pump hours	*Labour hours*	*Pump hours*	*Labour hours*	*Pump hours*	*Labour hours*	*Pump hours*	*Labour hours*
50	0·94	5·64	0·94	7·52	0·94	9·40	0·94	11·28
100	0·95	5·70	0·95	7·60	0·95	9·50	0·95	11·40
150	0·97	5·82	0·97	7·76	0·97	9·70	0·97	11·68
200	1·00	6·00	1·00	8·00	1·00	10·00	1·00	12·00
300	1·03	6·18	1·03	8·24	1·03	10·30	1·03	12·36
400	1·06	6·36	1·06	8·48	1·06	10·60	1·06	12·72
500	1·09	6·54	1·09	8·72	1·09	10·90	1·09	13·08
600	1·12	6·72	1·12	8·96	1·12	11·20	1·12	13·44
700	1·15	6·90	1·15	9·20	1·15	11·50	1·15	13·80
800	1·18	7·08	1·18	9·44	1·18	11·80	1·18	14·16
900	1·21	7·26	1·21	9·68	1·21	12·10	1·21	14·52
1000	1·24	7·44	1·24	9·92	1·24	12·40	1·24	14·88

Timbering shafts and basements in water-bearing ground

Note.—(1) The timberman and labourer hours shown are those taken in timbering per square yard of face.

(2) The data shown allows for both fixing and removing the timber.

(3) The timberman and labourer hours shown at the various lifts are applicable to the area of the timber in the lift to which they refer.

(4) The data shown for shafts is applicable to excavations up to 20 square yards in area and that for basements for areas in excess of this.

(5) The total cubic feet of timber required to timber the excavations per square yard of face is as follows:

Ground water content Gallons of water pumped per minute	*Shafts cu. ft. of timber per sq. yd. of face*	*Basements cu. ft. of timber per sq. yd. of face*
0–250	2·30	3·10
250–750	2·80	3·80
750–1500	3·30	4·50
1500–2500	3·80	5·20

(6) For purposes of estimating allow for "use and waste" of timber as follows:

Shafts .. .. 10 No. uses
Basements .. 12 No. uses

TIMBERING SHAFTS IN WATER-BEARING GROUND IN 5 FOOT LIFTS

Estimated gallons of water to be pumped per minute	*Depth of excavation in feet and timberman and labour hours timbering shafts in 5-ft lifts per sq. yd.*							
	1st lift, 0 to 5 ft.		*2nd lift, 5 to 10 ft.*		*3rd lift, 10 to 15 ft.*		*4th lift, 15 to 20 ft.*	
	Timb. hours	*Labour hours*	*Timb. hours*	*Labour hours*	*Timb. hours*	*Labour hours*	*Timb. hours*	*Labour hours*
0– 250	0·36	0·36	0·54	0·54	0·72	0·72	0·90	0·90
250– 750	0·48	0·48	0·72	0·72	0·96	0·96	1·20	1·20
750–1500	0·60	0·60	0·90	0·90	1·20	1·20	1·50	1·50
1500–2500	0·72	0·72	1·08	1·08	1·44	1·44	1·80	1·80

TIMBERING BASEMENTS IN WATER-BEARING GROUND IN 5 FOOT LIFTS

Estimated gallons of water to be pumped per minute	*Depth of excavation in feet and timberman and labour hours timbering basements in 5 ft lifts per sq. yd.*							
	1st lift, 0 to 5 ft.		*2nd lift, 5 to 10 ft.*		*3rd lift, 10 to 15 ft.*		*4th lift, 15 to 20 ft.*	
	Timb. hours	*Labour hours*	*Timb. hours*	*Labour hours*	*Timb. hours*	*Labour hours*	*Timb. hours*	*Labour hours*
0– 250	0·90	0·90	1·40	1·40	1·94	1·94	2·52	2·52
250– 750	1·20	1·20	1·87	1·87	2·59	2·59	3·36	3·36
750–1500	1·50	1·50	2·33	2·33	3·23	3·23	4·20	4·20
1500–2500	1·80	1·80	2·80	2·80	3·88	3·88	5·04	5·04

In order to illustrate the method of "building up" an estimate of the cost of excavation in water-bearing ground, a typical example is shown for excavating a trench in "running sand".

Example.—Estimate the cost of excavating, timbering, refilling and ramming a trench per lineal yard in "running sand", the following being the particulars pertaining to the excavation in question:

1. Depth of trench 9 ft and width 3 ft.
2. Assessed gallons of water to be pumped per minute = 500 gallons.
3. Type and size of pump selected to deal with the water, 5 in. diameter centrifugal.

For the purposes of this example the following rates are assumed:

1. Working cost or hire rate of pump per hour inclusive of driver fuel and oil .. .. = 6/- per hour
2. Timberman's rate .. .. = 2/3 „ „
3. Labourer's rate .. .. = 2/- „ „
4. Initial cost of timber used to timber the trench .. .. = 5/- per cu. ft.

Excavating, Refilling and Ramming the Trench per lineal yard

The total depth of trench is 9 ft., the depths in the various lifts being:

Depth of trench in the 1st lift of 0 to 5 feet .. .. .. = 5 feet
Depth of trench in the 2nd lift of 5 to 10 feet .. .. .. = 4 „

Total depth of trench .. .. = 9 feet

Referring to the table shown on page 191, the volume of excavation per lineal yard in a trench 9 ft. deep and 3 ft. wide under the various lifts is as follows:

1st lift, 0 to 5 feet .. .. = 1·67 cu. yds. (depth 5 ft.)
2nd lift, 5 to 10 feet .. .. = 1·33 „ „ (depth 4 ft.)

∴ Total cu. yds of excavation per lin. yd. .. .. = 3·00 cu. yds.

Referring to the table shown on page 195, the pump and labour hours taken per cubic yard to excavate, refill and ram trenches in water-bearing sand where the assessed amount of water to be pumped per minute is 500 gallons, is:

	Pump hours per cu. yd.	*Labour hours per cu. yd.*
1st lift, 0 to 5 feet	0·36	6·74
2nd lift, 5 to 10 feet	0·36	11·59

The cost per cubic yard is therefore:

1st lift, 0 to 5 feet

Pump hours = 0·36 hours at 6/- per hour .. .. = 2/2 per cu. yd.
Labourer hours = 6·74 hours at 2/- per hour .. .. = 13/6 „ „

∴ Cost of excavating, refilling and ramming 0 to 5 feet, inclusive of pumping .. .. = 15/8 per cu. yd.

2nd lift, 5 to 10 feet

Pump hours = 0·36 hours at 6/- per hour .. .. = 2/2 per cu. yd.
Labour hours = 11·59 hours at 2/- per hour .. .. = 23/2 „ „

∴ Cost of excavating, refilling and ramming 5 to 10 feet inclusive of pumping .. .. = 25/4 per cu. yd.

The cost of excavating, refilling and ramming the trench per lineal yard exclusive of timbering therefore is:

1st lift, 0 to 5 feet = 1·67 cu. yds. at 15/8 per cu. yd. .. = 26/2 per lin. yd.
2nd lift, 5 to 10 feet = 1·33 cu. yds. at 25/4 per cu. yd. .. = 33/10 „ „ „

∴ Cost of excavating, refilling and ramming the trench .. = 60/- per lin. yd.

Timbering the Trench per lineal yard

Referring to the table shown on page 196 for timbering in wet ground where the assessed amount of water to be pumped per minute is 500 gallons, the following data for estimating purposes are obtained:

1. Timberman and labourer hours timbering trench 9 ft. deep per lineal yard .. .. = 2·16 hrs. each
2. Quantity of timber required to timber the trench per lineal yard = 15·00 cu. ft.
3. The number of uses of the timber to allow for "use and waste" = 10 No.

Since the initial cost of the timber is 5/- per cubic foot, the number of uses No. 10 and the amount required per lineal yard of trench 15·00 cubic feet, the allowance for "use and waste" per lineal yard of trench is:

$$\frac{5 \text{ shillings}}{10 \text{ No. uses}} \times 15\cdot00 \text{ cu. ft.}$$

$$= 7/6 \text{ per lin. yd.}$$

The cost of timbering the trench is therefore:

Timberman = 2·16 hours at 2/3 per hour .. .. .. 4/10 per lin. yd.
Labour = 2·16 hours at 2/- per hour .. .. .. = 4/4 „ „ „
Allow for "use and waste" of timber .. .. = 7/6 „ „ „

∴ Cost of timbering trench .. .. = 16/8 per lin. yd.

The cost per lineal yard of excavating, timbering, refilling and ramming the trench is then:

Excavating, refilling and ramming .. .. = 60/- per lin. yd.
Timbering .. .. = 16/8 „ „ „

Total Cost .. .. = 76/8 per lin. yd.

Note.—In the above example the estimated cost of the timbered excavation averaged throughout the depth of the trench per cubic yard is:

The cost of excavating, timbering, refilling and ramming the trench per lineal yard divided by the total cubic yards of excavation in the trench per lineal yard.

$$= \frac{76/8}{3 \text{ cu. yds.}}$$

$$= 25/7 \text{ per cu. yd.}$$

SECTION FIFTEEN

★

FENCER

The common types of fencing, generally erected by the civil engineer himself, are shown in this Section.

For fences in brickwork or concrete, the data shown under these sections should be used to build up the estimate.

On a contract where a large amount of fencing of types other than those indicated in this Section have to be erected, such as wrought-iron fencing, etc., it is good policy to ask for estimates from two or more of the well-established firms who specialise in fencing works, and use these on which to base the estimate, adding a reasonable percentage to allow for a small margin of profit.

In the event of the contract being secured, the fencing can then be sublet if this should be desirable, and a profit assured.

The data shown assumes that the fencing materials are off-loaded from lorries adjacent to the site where they are fixed.

If the access is such that the fence posts, etc. have to be manhandled to the position where they are fixed such additional handling costs should be assessed and allowed for in addition.

For timber fences and sundry work to fencing see page 202.

FENCES WITH CONCRETE POSTS

Item	*Unit*	*Labourer hours*
Excavate post holes, 1′ 6″ deep	each	0·30
,, ,, ,, 2′ 0″ ,,	,,	0·50
,, ,, ,, 2′ 6″ ,,	,,	0·70
Excavate holes for gate-posts	,,	0·90
Concrete filling to post holes	cu. ft.	0·28
Off-load and fix posts 4′ 6″ long, let 1′ 6″ into ground	each	0·30
,, ,, ,, ,, 5′ 6″ ,, ,, 2′ 0″ ,, ,,	,,	0·45
,, ,, ,, ,, 6′ 0″ ,, ,, 2′ 0″ ,, ,,	,,	0·54
,, ,, ,, ,, 7′ 0″ ,, ,, 2′ 0″ ,, ,,	,,	1·10
,, ,, ,, ,, 8′ 0″ ,, ,, 2′ 6″ ,, ,,	,,	1·50
,, ,, ,, ,, gate-posts	,,	1·60
,, ,, ,, ,, struts to 4′ 6″ posts	,,	0·50
,, ,, ,, ,, ,, 5′ 6″ ,,	,,	0·70
,, ,, ,, ,, ,, 6′ 0″ ,,	,,	0·80
,, ,, ,, ,, ,, 7′ 0″ ,,	,,	1·60
,, ,, ,, ,, ,, 8′ 0″ ,,	,,	2·20
Fix eye-bolts	,,	0·25
Fix No. 6 gauge wire, single strand	lin. yd.	0·06
,, ,, 8 ,, ,, ,, ,,	,,	0·05
,, ,, 10 ,, ,, ,, ,,	,,	0·04
,, barbed wire, ,, ,,	,,	0·10
,, chain link fencing to posts, 3′ 0″ high	,,	0·20
,, ,, ,, ,, ,, ,, 4′ 0″ ,,	,,	0·30
,, ,, ,, ,, ,, ,, 5′ 0″ ,,	,,	0·40
,, ,, ,, ,, ,, ,, 6′ 0″ ,,	,,	0·50

FENCES WITH WOODEN POSTS

Item	*Unit*	*Labourer hours*
Excavate post holes, 1′6″ deep	each	0·30
,, ,, ,, 2′0″ ,,		0·50
,, ,, ,, 2′6″ ,,		0·70
,, for gate-posts		0·90
Concrete filling to post holes	cu. ft.	0·28
Off-load and fix posts, 4′ 6″ long, let 1′ 6″ into ground	each	0·25
5′ 6″ ,, ,, 2′ 0″ ,, ,,		0·36
6′ 0″ ,, ,, 2′ 0″ ,, ,,		0·45
7′ 0″ ,, ,, 2′ 0″ ,, ,,		0·90
0″ ,, ,, 2′ 6″ ,, ,,		1·20
gate-posts		1·25
struts to 4′ 6″ posts		0·40
5′ 6″ ,,		0·60
6′ 0″ ,,		0·70
7′ 0″ ,,		1·30
8′ 0″ ,,		1·80
Tar foot of posts, 0·05 gallons per post		0·12
,, ,, ,, gate-posts		0·20
Fix 3″×2″ rails	lin. yd.	0·12
4″×2″ ,,		0·15
No. 6 gauge wire, single strand		0·06
8 ,, ,, ,, ,,		0·05
10 ,, ,, ,, ,,		0·04
barbed wire		0·10
pipe rail, 1″ dia.		0·30
1½″ ,,		0·45
2″ ,,		0·60
Arris rails out of 3″×3″		0·12
4″×3″		0·18
boarding, ships lap-boarded fence	sq. yd.	0·30

Note.—For fences erected in oak or hardwood use a Labour Hour Multiplier for fixing posts, rails, Arris rails, and boarding of 1·50.

CLEFT CHESTNUT FENCING

Item	*Unit*	*Labourer hours*
Fix fencing 3′ high with posts at 6′ centres	lin. yds.	0·35
4′ ,, ,, ,, ,, 6′		0·45
5′ 6′		0·55
3′ 9′		0·25
4′ 9′		0·35
5′ 9′		0·45

FENCING—SUNDRY WORKS

Item	*Unit*	*Labourer hours*	*Carpenter hours*
Fix gates, field type (hang only)	each	0·80	
,, double hung type (,, ,,)	,,	1·50	
,, gate hinges (heavy)	per pair	2·00	2·00
,, gate latches	each	—	0·50
,, wire netting only to wood post fence 2′ high	lin. yd.	0·10	
,, ,, ,, ,, ,, ,, ,, ,, 3′ ,,		0·12	
,, ,, ,, ,, ,, ,, ,, ,, 4′ ,,		0·15	

MASON

RANDOM RUBBLE WALLS

Thickness of walls	*Mortar per sq. yd. in cu. yds.*	*Stones tons required per sq. yd.*	*Mason hours per sq. yd.*	*Labourer hours per sq. yd.*
12 in. per sq. yd.	0·08	0·54	1·5[illegible]	2·20
15 in. ,, ,,	0·10	0·66	1·[illegible]0	2·70
18 in. ,, ,,	0·12	0·80	2·20	3·20
Pointing walling per sq. yd.	0·02	—	0·50	0·25

Note.—Stone taken as 150 lb. per cu. ft. and stones average 6 in. deep random rubble walls, per sq. yd.

ASHLAR WALLING

Ashlar walling	*Mason hours*	*Labourer hours*
Hoist and fix ashlar, per cu. ft.	0·44	0·66
Clean down ,, per sq. ft.	—	0·46
Rake and point ,, per sq. yd.	0·60	0·30
Tooled faces to ,, per sq. ft.	1·40	
Hammer square to ashlar, per sq. ft.	1·00	

GRANITE SETT CHANNELS AND ROADS, YARDS, ETC.

Item	*Mason hours*	*Labourer hours*	*7/5 concrete mixer hours*
Clean down old setts for re-use, per lin. yd.	—	0·20	—
Excav. for setts and load to lorries, per cu. yd.	—	3·00	—
Mix and place only concrete in foundation and haunch to setts, per cu. yd.	—	3·20	0·40
Mortar required per sq. yd. of setts=0·80 cu. ft.	—	—	—
Off-load and lay 4 × 4 setts, 4 in. deep per sq. yd.	0·80	0·8C	—
,, ,, 4×5 ,, 5 in. ,, ,, ,,	0·90	0·90	—
,, ,, 4×6 ,, 6 in. ,, ,, ,,	1·00	1·00	—
,, ,, one row of 4 × 4 in. setts and joint, per lin. yd.	0·16	0·24	—
,, ,, one row of 4×5 in. setts and joint, per lin. yd.	0·17	0·25	—
,, ,, one row of 4×6 in. setts and joint, per lin. yd.	0·18	0·27	—
Remove setts	—	0·40	—

Note.—(1) Setts assumed d/d site in lorries. If not, add haulage and loading, but not off-loading, per lin. yd. or per sq. yd. to site.

(2) For haulage of excavation to tip, see pages 154 and 157.

(3) For haulage of concrete, see page 138.

(4) If concreting by hand, or with various sizes of mixers, see pages 128 and 129.

(5) For mortar table and cost of mixing mortar, see page 208.

KERB—CONCRETE OR GRANITE

Item	*Mason hours*	*Labourer hours*	*7/5 concrete mixer hours*
Excav. for kerb and load to lorries, per cu. yd.	—	2·90	—
Off-load, lay, and joint, 5 × 10 concrete kerb, straight, per lin. yd.	0·14	0·28	—
Off-load, lay, and joint, 5 × 10 concrete kerb, radius, per lin. yd.	0·21	0·42	—
Off-load, lay, and joint, 5 × 10 granite kerb, straight, per lin. yd.	0·16	0·32	—
Off-load, lay, and joint, 5 × 10 granite kerb, radius, per lin. yd.	0·24	0·48	—
Off-load, lay, and joint, 12 × 6 concrete kerb, straight, per lin. yd.	0·18	0·36	—
Off-load, lay, and joint, 12 × 6 concrete kerb, radius, per lin. yd.	0·27	0·54	—
Off-load, lay, and joint, 12 × 6 granite kerb, straight, per lin. yd.	0·24	0·48	—
Off-load, lay, and joint, 12 × 6 granite kerb, radius, per lin. yd.	0·36	0·72	—
Off-load, lay, and joint, 5 × 2 concrete path edging, per lin. yd.	0·12	0·24	—
Off-load, lay, and joint, 7 × 2 concrete path edging, per lin. yd.	0·14	0·28	—
Concreting under, and haunching to kerb, per cu. yd., mix and place only	—	3·20	0·40

Note.—(1) Constants assume kerb d/d site by lorry. If not, add haulage per lin. yd. to site, including loading but *not* off-loading.

(2) For haulage of excavation to tip, see pages 154 and 157.

(3) For haulage of concrete, see page 138.

(4) For concreting by hand or with various sizes of concrete mixers, see pages 128 and 129.

LAYING "GED" KERB

Item	*Lay and joint "GED" kerb per lin. yard*							
	"GED" kerb flat type				*"GED" kerb edge type*			
	Mortar Reqd. cu. ft.	*Grout Reqd.* cu. ft.	*Mason* hrs.	*Lab.* hrs.	*Mortar Reqd.* cu. ft.	*Grout Reqd.* cu. ft.	*Mason* hrs.	*Lab.* hrs.
Insert 2 No. dowels in road slab and grout in	—	0·012	0·03	0·08	—	0·012	0·03	0·08
off-load and lay kerb	0·17	—	0·10	0·24	0·12	—	0·08	0·16
Total per lin. yd. ..	0·17	0·012	0·13	0·32	0·12	0·012	0·11	0·24

Note.—(1) Two dowels ¾ in. diameter × 6 in. long are required per kerb.

(2) The data shown are for off-loading, laying and jointing one lin. yard of kerb complete including inserting and grouting the dowels.

(3) For mortar for bed allow 3 to 1 cement mortar and for grout 1 to 1 cement grout.

(4) The labour hours shown allow for "Knocking up" the mortar and mixing the grout.

"GED" PRECAST CONCRETE KERB LAID ON CONCRETE ROADS

"Ged" Kerb (Fig. 26), is manufactured exactly as any other concrete kerb, i.e. in moulds where it is vibrated. The aggregates used can be of gravel, shingle, granite, limestone or any other suitable aggregate, sand and cement. It can be made to any cross section or size, in accordance with the British Standard Specification, and the cross section shown on the drawing allows for the camber of the concrete road raft ensuring slight fall of the top face of the kerb towards the road channel and *not* back fall towards the footpath.

The difference between "Ged" Kerb and ordinary kerb is that each kerb has cast in it, as shown in the drawing, 2 No. ½ in. grout holes leading to two grout chambers, which fit over 2 No. ¾ in. dowels inserted in the road carriageway when the road is constructed. The kerb is laid on a mortar bed on the carriageway and liquid grout is then poured through the grout holes into the chambers. The kerb is thus held firmly to the road slab through the medium of the dowels, and can in no way slide on the road slab.

Insertion of Reflector Studs

It will be noted on the drawing that the grout holes can be in alternative positions relative to the kerb. If the grout holes are on the top. ½ in. dia. reflector studs may be inserted in the grout holes after the grout has been poured, the kerb then becoming a reflector kerb lit up both by car lights and lamp-posts. If no reflector kerb is desired the grout holes may be where shown at the back of the kerb, being simply grouted up and flushed off in mortar. Grout may either be poured in through a funnel or by hand pump.

In the event of a kerb being broken at any time, it is a perfectly simple matter to replace it with a new one, the broken kerb being removed and the new one laid over the dowels on a mortar bed in the usual way, the grout then being poured through the filler holes.

Placing of Dowels

The placing of the dowels in the road slab is done by means of a steel or aluminium template as shown on the drawing (Fig. 26). These templates may be purchased from the kerb suppliers, or alternatively they may be hired out at a charge to cover wear and tear.

Advantages of "GED" Kerb laid flat on Concrete Road Slab, or clear of it on a Concrete Foundation

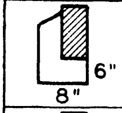
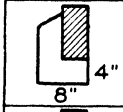
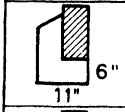
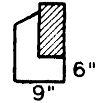
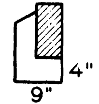
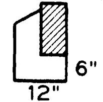
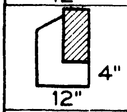
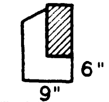
1. "Ged" Kerb is firmly dowelled to the road slab and forms a sound fender to traffic and a firm abutment for the path, and can in no way slide on the road slab.

2. Being laid on the road slab prior to building operations it ensures that the road slab edges are not damaged by heavy lorries running or backing over the edge of the road.

3. If ½ in. reflector studs are inserted it forms a reflector kerb.

4. No concrete backing whatsoever is required thus saving time and cost.

5. The laying costs as compared with kerb laid clear of the road slab on a separate concrete foundation with the kerb backed in concrete are considerably less. The excavation by hand in narrow trenches and the concreting of small foundations and in backing, is both slow and costly.

SECTION	5" x 10" EDGE KERB		6" x 12" EDGE KERB
	C.YARDS EXCAVATION CONCRETE	 0·074 0·048	C YARDS – –
	EXCAVATION CONCRETE	0·070 0·037	– –
	EXCAVATION CONCRETE	0·100 0·077	– –
	EXCAVATION CONCRETE	0·088 0·063	– –
	EXCAVATION CONCRETE	0·080 0·055	0·08 0·05
	EXCAVATION CONCRETE	– –	0·110 0·083
	EXCAVATION CONCRETE	– –	0·100 0·070
	EXCAVATION CONCRETE	– –	0·080 0·060

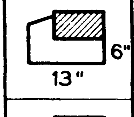
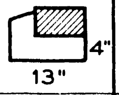
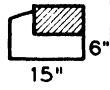
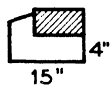
SECTION	10" x 5" FLAT KERB		12" x 6" FLAT KERB
	C. YARDS EXCAVATION CONCRETE	 0·120 0·070	C YARDS – –
	EXCAVATION CONCRETE	0·100 0·048	– –
	EXCAVATION CONCRETE	– –	0·140 0·078
	EXCAVATION CONCRETE	– –	0·120 0·053

Fig. 25 shows the volume in cubic yards per lin. yard of Excavation and Concrete for Kerb laid on various thicknesses and widths of concrete. Excavation assumed 12 inches deep.

6. Since this kerb is laid on the road slab the excavation and concrete for the kerb is cheap, as the excavation is done while excavating the road by mechanical plant and the concrete is placed in bulk with the carriageway.

7. It can be laid at a fast rate of progress close behind the completed road slab, little labour or plant being required.

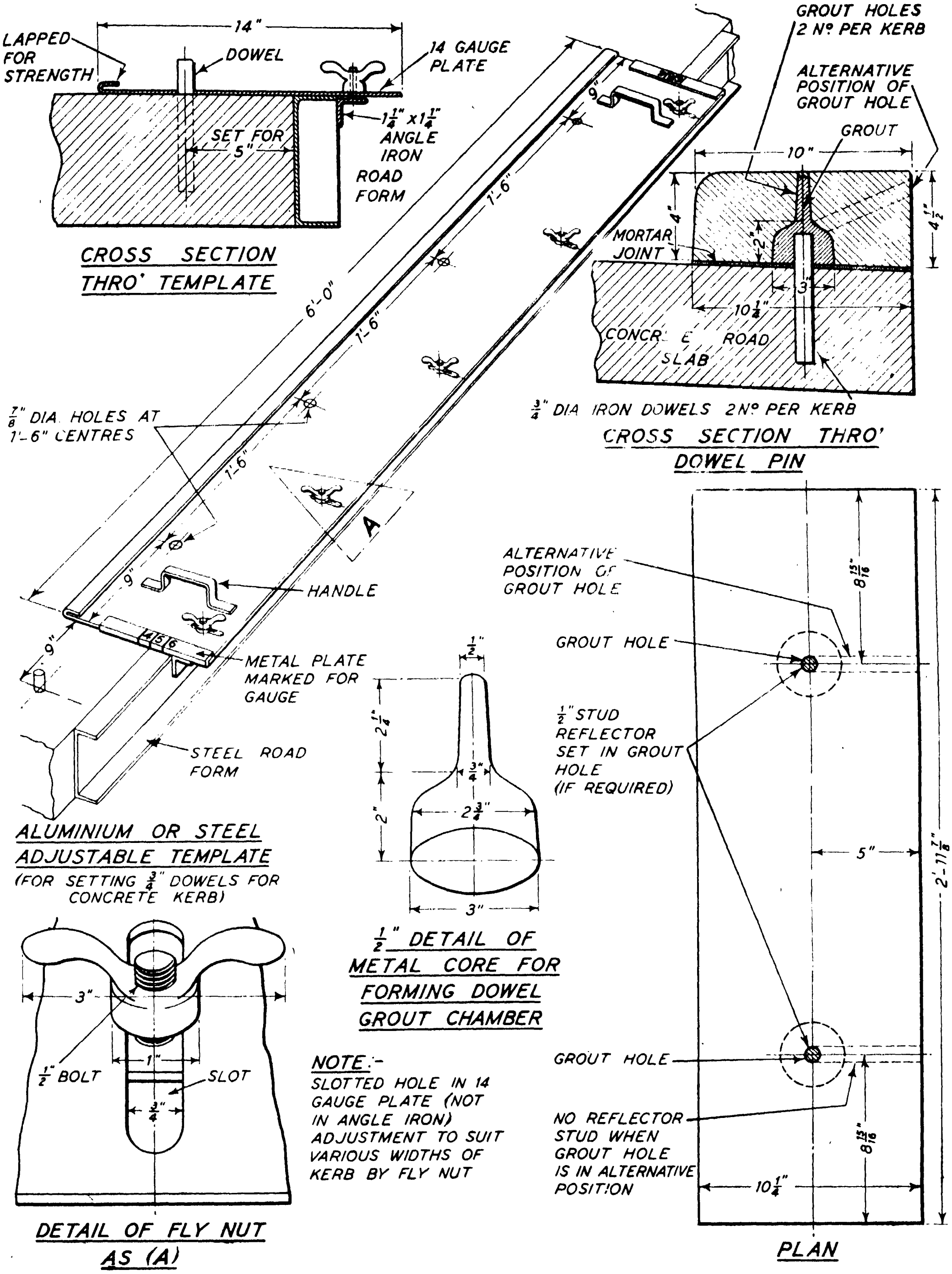
8. As compared with normal kerb laying as now generally carried out it offers a firm immovable kerb when laid and has everything to recommend its use, both from a cost laid per lineal yard, and from the speed of laying.

WEIGHT OF SETTS, ONE ROW PER LIN. YARD

Size of sett in inches	*Tons per 1 yd. single row*
3 × 3 deep	0·013
3 × 4 ,,	0·020
3 × 5 ,,	0·024
3 × 6 ,,	0·026
4 × 4 ,,	0·025
4 × 5 ,,	0·030
4 × 6 ,,	0·038
5 × 5 ,,	0·040
5 × 6 ,,	0·050

AREA COVERED BY 1 TON

Size of sett in inches	*Sq. yds. covered by 1 ton*
3 × 3 deep	7
4 × 4 ,,	5½
4 × 5 ,,	4½
5 × 5 ,,	4¼
5 × 6 ,,	4



CROSS SECTION THRO' TEMPLATE

CROSS SECTION THRO' DOWEL PIN

ALUMINIUM OR STEEL ADJUSTABLE TEMPLATE (FOR SETTING ¾" DOWELS FOR CONCRETE KERB)

½" DETAIL OF METAL CORE FOR FORMING DOWEL GROUT CHAMBER

DETAIL OF FLY NUT AS (A)

PLAN

NOTE:- SLOTTED HOLE IN 14 GAUGE PLATE (NOT IN ANGLE IRON) ADJUSTMENT TO SUIT VARIOUS WIDTHS OF KERB BY FLY NUT

LAPPED FOR STRENGTH
14"
DOWEL
14 GAUGE PLATE
SET FOR 5"
1¼" x 1¼" ANGLE IRON ROAD FORM
GROUT HOLES 2 Nº PER KERB
ALTERNATIVE POSITION OF GROUT HOLE
GROUT
10"
4"
4½"
2"
MORTAR JOINT
3"
10¼"
CONCRETE ROAD SLAB
¾" DIA IRON DOWELS 2 Nº PER KERB
9"
1'-6"
6'-0"
⅞" DIA HOLES AT 1'-6" CENTRES
A
HANDLE
4 5 6
METAL PLATE MARKED FOR GAUGE
STEEL ROAD FORM
½"
2¼"
¾"
2¾"
ALTERNATIVE POSITION OF GROUT HOLE
GROUT HOLE
½" STUD REFLECTOR SET IN GROUT HOLE (IF REQUIRED)
8 15/16"
5"
2'-11⅞"
GROUT HOLE
NO REFLECTOR STUD WHEN GROUT HOLE IS IN ALTERNATIVE POSITION
½" BOLT
SLOT
1"

FIG. 26.—DETAILS OF "GED" PRECAST CONCRETE KERB LAID ON CONCRETE CARRIAGEWAY

Note.—This kerb can be made to any suitable cross section.

OFF-LOAD AND LAY PAVING SLABS PER SQUARE YARD

Note.—The hours shown do not allow for "knocking up" mortar.

Per sq. yd.	*2 in. slabs*	*2½ in. slabs*
Mason hours	0·28	0·35
Labourer hours	0·28	0·35
Cu. yds. mortar required per sq. yd.	0·02	0·02

CEMENT AND LIME MORTARS

Cubic yards of sand and tons of cement and lime required to make 1 cubic yard of mortar of various mixes.

Mix		*Cement mortar*		*Lime mortar*	
Sand	*Cement*	*Sand*	*Cement*	*Sand*	*Lime*
1	1	0·73	0·79	0·73	0·40
1½	1	0·93	0·67	0·93	0·33
2	1	1·00	0·54	1·00	0·27
2½	1	1·07	0·46	1·07	0·23
3	1	1·10	0·39	1·10	0·20
3½	1	1·15	0·33	1·15	0·17
4	1	1·20	0·29	1·20	0·15

For mixing mortar allow:

Lime mortar 5·00 labour hours per cu. yd.
Cement mortar 6·00 labour hours per cu. yd.

Note.—The data shown relating to sand refer to dry sand. If washed sand is used, a multiplier of 1·25 should be used in conjunction with the quantities of sand shown, to allow for bulkage due to moisture content.

AVERAGE WEIGHT OF BUILDING STONE

	Lbs. per cu. ft.	*Cu. ft. per ton*
Bath	140	16
Portland	150	15
Sandstone ..	150	15
York	154	14½
Limestone ..	154	14½
Purbeck	160	14
Granite	166	13½
Marble	172	13

SECTION SEVENTEEN

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PAINTER AND GLAZIER

Painting data is rather difficult to compile accurately. The carrying out of the work varies considerably both as regards labour and material. Some painters use more paint than others; some woods and materials absorb more paint than others; some paints are thicker in cold weather than in hot, hence covering less area. The data for materials required per sq. yd. and the "painter hour" must, therefore, allow for such factors, and the striking of fair averages is the best solution.

The data shown in the tables makes fair average allowance for the above factors and may be used in most cases for estimating purposes. If, however, the estimator knows that the surface which has to be painted is extremely rough or absorbent or in the case of steel or iron, that it is rusty, he may, to be on the safe side, reduce the covering capacity of the paint by a factor that may be as high as 20%.

In the past few years a considerable amount of paint-spraying work has been carried out using pressure-spraying plant. This plant consists of a small petrol engine driving a small compressor. The paint is contained in air-tight drums into which the compressed air is fed through rubber tubes at a pressure of about 60 lb./sq. in. The paint is then ejected through another tube at the end of which is fitted a spray gun, fitted with a nozzle controlled by a trigger. The rate of application depends on:

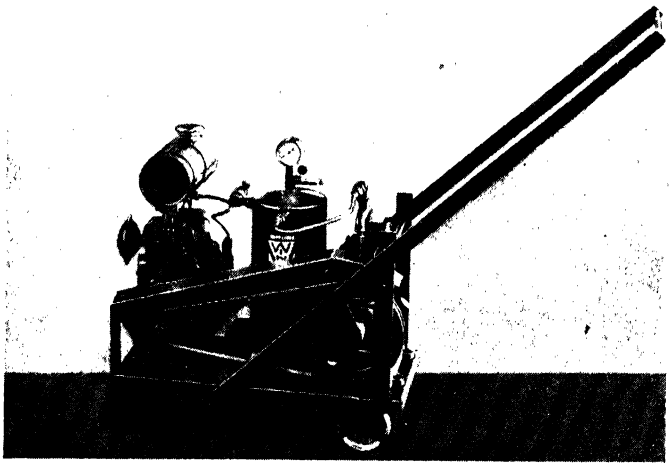
(1) The viscosity of the paint.

(2) The nature of the surface to be painted.

Thin paint, such as the type used during wartime for camouflage work, can be applied at a faster rate than the thicker oil paints.

It is essential that the plant, particularly the paint hoses and spray guns, should be kept clean. The hoses should be blown clear with compressed air at the end of every working session. The spray guns should be thoroughly washed in paraffin and nozzles removed and cleared of all paint. The machines are used extensively where large areas have to be covered, such as painting railway wagons with oil paints, War Department camps, aerodromes, buildings, etc.

A table is shown for using oil paints. The areas covered by 1 gallon to various surfaces are also



Winchester Machine Tool Co. Ltd.

FIG. 27.—"WINCO" MODEL 6 PORTABLE MOTORISED SPRAYING PLANT, 6 CU. FT. COMPRESSOR, ¾ H.P. MOTOR (EITHER ELECTRIC OR PETROL ENGINE)

shown. An example is given of the cost per sq. yd. for this type of work. In carrying out this work the machine was serviced by the leading hand in charge, who also applied paint with a spray gun. The machine hours and labour hours per sq. yd. are shown for one, two, and three guns, as these machines are capable of working one to three spray guns comfortably. It is therefore more economical to use the maximum number of guns with the one plant.

Example:

Calculate the cost per sq. yd. to paint spray brick walls with oil paint, using two spray guns, assuming:

Plant cost, complete with containers and guns, £180.
Paint cost 10/- per gallon.
Labour rate applying paint 2/6 per hour.

Note.—One of the men on the guns services the machine, filling up with petrol and oil as required.

PAINTING BY PRESSURE-SPRAYING PLANT USING OIL PAINT PER SQUARE YARD

Type of surface sprayed	*Area covered by 1 gall. of paint sq. yds.*	*Area sprayed per gun per hour sq. yds.*	*Plant hours per sq. yd. using*			*Labour hours per sq. yd.*
			1 gun	*2 guns*	*3 guns*	
Asbestos sheets	30	27	0·037	0·019	0·012	0·037
Brick walls	25	24	0·042	0·021	0·014	0·042
Corrugated iron	35	30	0·033	0·017	0·011	0·033
Sheet iron	40	36	0·030	0·015	0·010	0·030
Tiles	20	21	0·048	0·024	0·016	0·048
Wood	35	30	0·033	0·017	0·011	0·033

Working Cost of Plant per hour

Initial cost on plant	= £180 0 0
Add 5% interest on outlay for 5 years	= £45 0 0
	£225 0 0
Allowing a 5-year life cost per annum	= $\frac{£225}{5}$
	= £45 0 0
Allowing, say, 1,000 working hours per annum	
Cost per working hour	= $\frac{£45\ 0\ 0}{1,000}$
	= 10·80 pence per hour
Allow for repairs and renewals, 32%	= 2·93 ,, ,,
	13·73 ,, ,,
Petrol cost per hour, say ½ gall. at 2/-	= 12·00 ,, ,,
Lubricating oil and grease, say	= 2·00 ,, ,,
Insurance, say	= 1·00 ,, ,,
∴ Total working cost per hour	= 28·73 ,, ,,
	= 2/5 per hour.

Cost per sq. yd. using 2 Guns

From tables:
Working cost of plant per sq. yd. = 0·021 hours at 2/5 = 0·60 pence
Labour cost per sq. yd. = 0·042 „ „ 2/6 = 1·26 „
Paint cost per sq. yd. = $\frac{1}{25}$ × 10/- per gallon = 4·80 „

∴ Total cost per sq. yd. .. 6·66 „
Say 6⅔*d*. per sq. yd.

Glazier

Sheet glass can be obtained in various weights, such as 15 oz., 21 oz., 26 oz. per sq. ft., and these are the weights most commonly used.

GLAZING

Description	*Unit*	*Glazier hours*
Glaze with 15 oz.	sq. ft.	0·18
„ „ 21 „	„	0·19
„ „ 26 „ .. .	„	0·20

Painting by Hand and Brush

COVERING CAPACITY OF PAINT PER GALLON IN SQUARE YARDS

Description	*Unit*	*Priming coat*	*White paint*	*Coloured paints*	*Varnish*
On brickwork or stone ..	sq. yds.	40	50	60	—
On woodwork	„	70	80	90	90
On ironwork	„	80	100	110	—

Description	*Unit*	*Materials required*			*Painter hours*
		Distemper lb.	*Paint lb.*	*Stain, creosote or varnish galls.*	
Creosoting one coat	sq. yd.	—	—	0·04	0·24
Distemper walls, 1 coat	„	0·30	—	—	0·06
Paint steel joists, 1 coat	„	—	0·34	—	0·40
„ „ „ 2 coats	„	—	0·65	—	0·70
„ „ „ 3 „	„	—	1·00	—	1·00
„ 4 in. gutters, 1 coat	lin. ft.	—	0·04	—	0·04
„ 5 in. „ 1 „	„	—	0·05	—	0·05
„ 3 in. rainwater pipes, 1 coat	„	—	0·02	—	0·02
„ 4 in. „ „ 1 „	„	—	0·03	—	0·03
„ steel casements, 1 coat	sq. ft.	—	0·02	—	0·06
„ letters per 1 in. depth	No.	—	0·01	—	0·15
„ woodwork, 1 coat, including knotting and stopping	sq. yd.	—	0·28	—	0·22
„ woodwork, 2 coats, including knotting and stopping	„	—	0·50	—	0·40
„ woodwork, 3 coats, including knotting and stopping	„	—	0·70	—	0·60
Stain woodwork, 1 coat	„	—	—	0·02	0·15
Varnish „ 1 „	„	—	—	0·02	0·30

SECTION EIGHTEEN

★

PILE DRIVER

Piling is resorted to by the contractor when constructing new work in several instances such as:

1. The construction of new wharves or jetties.

2. The construction of coffer-dams in which to build new work, such as bridge foundations, etc.

3. The construction of coffer-dams in order to lay pipes, etc., across rivers or canals, etc.

4. The sheet piling of very wet ground to take the place of trench timber. In this case the excavation is removed after the piles have been driven, and the piles strutted out as the excavation is taken out.

The tables shown show constants for:

1. Reinforced concrete piles.
2. Pitch pine piles.
3. Larssen sheet piles as used for coffer-dams, etc.

The constants do not include for the preparation of ground to receive the piling frame, levelling off to a flat surface, laying sleepers, etc., nor loading and unloading. This must be allowed for in making up the tender and will, of course, vary with different sites and conditions.

If the work is tidal the constants should be multiplied by 1·30.

There are many specialist firms throughout the country who specialise in this class of work, and if extensive piling has to be carried out the estimator is well advised to get quotations for the work from two or more of these firms and use these on which to base his estimate. A small margin of profit can be added and in the event of his securing the contract the piling work could, if desired, be let out as a sub-contract and a margin of profit assured.

Examples are shown for coffer-damming for bridge foundation work and for steel sheet piling work.

ERECTING AND DISMANTLING PILING PLANT ON THE SITE

Note.—(1) The hours shown in the following table represent those for the plant erected on reasonably level ground.

(2) If the plant has to be erected on pontoons or barges a Multiplier of 1·50 should be used with the hours shown.

(3) If rails on sleepers have to be laid in excess of 100 lin. ft. this excess should be allowed for. See "Platelayer" Section, page 241.

(4) The haulage cost of the plant to site must be taken into account.

ERECTING AND DISMANTLING PILING PLANT

Type of Plant		*Unit*	*Total Labour hours to erect and dismantle the plant*
Standard Type Steel Piling Frame	20 ft. high . .	each	340
	35 ft. „ . .	„	600
	50 ft. „ . .	„	800
	65 ft. „ . .	„	910
	80 ft. „ . .	„	1040
Light Type Piling Frame	20 ft. „ . .	„	310
	25 ft. „ . .	„	390
	35 ft. „ . .	„	550
	50 ft. „ . .	„	740
1 Ton Crane or Derrick		„	530
3 „ „ „		„	630
5 „ „ „		„	720

PILING—VARIOUS

Note.—(1) The Constants shown are for piling in Non-Tidal Waters such as canal or river piling. Use Table of Multipliers shown on page 215 for other classes of work.

(2) For extracting concrete or timber piles, use a Multiplier of 0·80 with the hours shown for handling, pitching and driving.

(3) For extracting steel sheet piling, use a Multiplier of 0·80 with the hours shown for handling pitching and driving.

TIMBER PILING

Description	*9 in.×9 in. Pitch pine piles*			*12 in.×12 in. Pitch pine piles*		
	Piling frame hours	*Carpenter hours*	*Labourer hours*	*Piling frame hours*	*Carpenter hours*	*Labourer hours*
Unload, handle and pitch vertically, per lin. ft. . .	0·04	—	0·40	0·05	—	0·55
Drive vertically, per lin. ft. . .	0·03	—	0·24	0·04	—	0·32
Unload, handle and pitch raking, per lin. ft. . .	0·05	—	0·65	0·06	—	0·84
Drive Raking, per lin. ft.	0·04	—	0·36	0·05	—	0·45
Ring shoe and bore toggle holes, per pile	—	1·80	1·80	—	2·20	2·20
Cut off heads, each	—	0·40	0·40	—	0·50	0·50
Fix Braces, per cu. ft. . .	—	0·45	0·45	—	0·45	0·45
Fix Coping, per cu. ft. . .	—	0·60	0·60	—	0·60	0·60
Fix Deck Planking, per cu. ft.	—	0·30	0·30	—	0·30	0·30
Fix Struts, per cu. ft. . .	—	0·50	0·50	—	0·50	0·50
Fix Walings, per cu. ft. . .	—	0·40	0·40	—	0·40	0·40

CONCRETE PILING

Description	*9 in.×9 in. Concrete piles*		*12 in.×12 in. Concrete piles*	
	Piling frame hrs.	*Labourer hours*	*Piling frame hours*	*Labourer hours*
Unload, handle and pitch vertically, per lin. ft.	0·07	0·77	0·08	0·96
Drive vertically, per lin. ft.	0·04	0·32	0·05	0·40
Unload, handle and pitch raking, per lin. ft. . .	0·09	1·26	0·10	1·40
Drive raking, per lin. ft.	0·05	0·45	0·07	0·63
Bend and Hook Bars up to ¾ in. dia. each . .	—	0·20	—	0·20
„ „ „ „ ¾ to 1 „ „ . .	—	0·25	—	0·25
„ „ „ „ 1 to 1½ „ „ . .	—	0·30	—	0·30
Break down heads	—	3·00	—	4·00

STEEL SHEET PILING

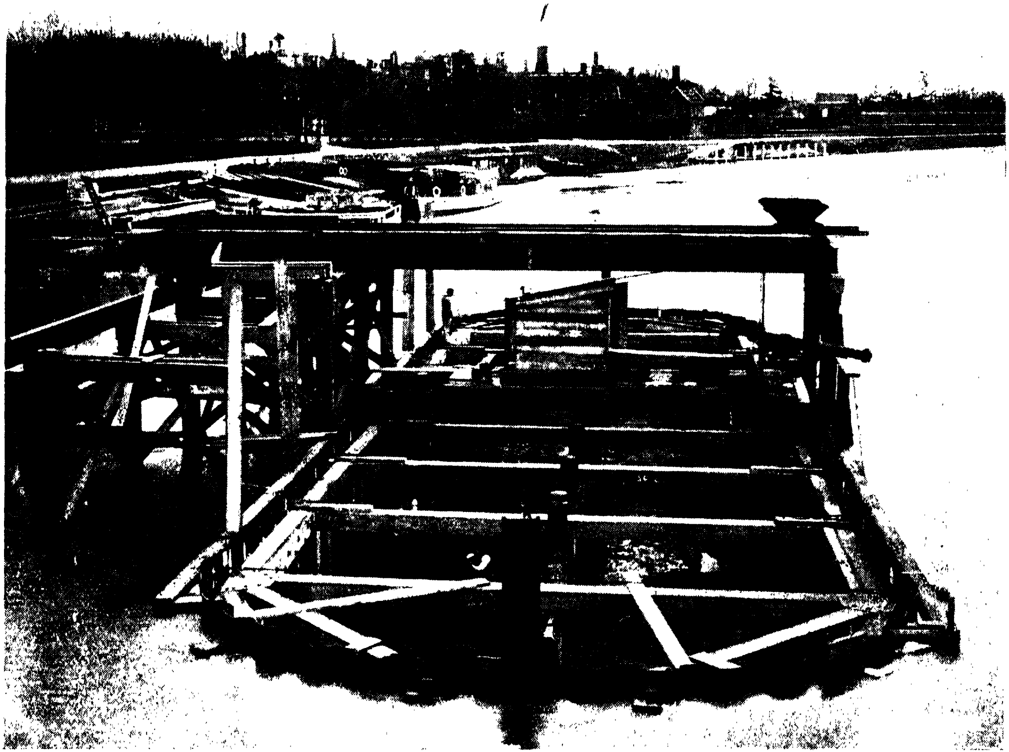
Description	*No. OGB Steel sheet piling*	
	Piling frame hours	*Labour hours*
Unload, handle and pitch vertically, per lin. ft.	0·04	0·40
Drive vertically ,, ,,	0·03	0·24
Unload, handle and pitch raking, ,, ,,	0·05	0·60
Drive raking ,, ,,	0·04	0·36
Burn off tops to ⅜ in. thick ,, ,,	—	0·20
,, ,, ,, ⅜ to ⅝ ,, ,, ,,	—	0·22
,, ,, ,, ⅝ to ¾ ,, ,, ,,	—	0·24
Extra to pitch and drive corner piles ,, ,,	0·05	0·40
Extra to pitch and drive junction piles ,, ,,	0·06	0·48

Note.—(1) In calculating the extra to pitch and drive corner or junction piles, take total overall length of the pile.

(2) Constants assume piles not less than 15 ft. long.

Table of Multipliers for use with Steel Sheet Piling Table, for Piles of Sections other than OGB

Type of piling section	*Plant and labour hour multipliers*
OGB	1·00
1GB	1·10
1U	1·20
2	1·30
3	1·50
4B	1·70
5	2·00
10A	1·40



The British Steel Piling Co. Ltd.

FIG. 28.—COFFER-DAM OF LARSSEN, SECTION NO. 2, THE PILES ARE FISH-PLATED AND HAVE LOWER LENGTHS LEFT PERMANENTLY IN PLACE FOR PROTECTION AGAINST SCOUR

TABLE OF MULTIPLIERS FOR USE WITH THE TABLES SHOWN FOR TIMBER, CONCRETE AND STEEL SHEET PILING

Description	*Plant and labour hour multiplier*
Driving Piles in Non-Tidal water such as Canal or River Piling	1·00
Driving Piles in Tidal water	1·30
Driving Piles on ground such as for Building Foundations, etc.	0·75
Driving Piles from Pontoons or Barges in Tidal water	1·60
Driving Piles from Pontoons or Barges in Non-Tidal water	1·30

Example No. 1

Coffer-dams.—Construct coffer-dam for a bridge foundation 60 ft. long, with two end returns to river bank 10 ft. long each. Larssen sheet piling O.G.B. 11 in. wide, labour 2/- per hour. Piles 15 ft. long, driven 6 ft. Piles left in. Non-Tidal water.

From Tables

Cost per ft. to off-load handle and pitch.	Labourer hours, 0·40 at 2/- ..	9·60
„ „ pile frame hours.	„ „ 0·04 at 15/-	7·20
	Pence per ft.	16·80
Cost per ft. to drive.	Labourer hours, 0·24 at 2/-	5·76
	Pile frame hours, 0·03 at 15/-	5·40
	Pence per ft.	
Extra for corners, per ft.	Labourer hours, 0·40 at 2/-	9·60
	Pile frame hours, 0·05 at 15/-	9·00
	Pence	18·60

Total lin. ft. of piles round coffer-dam = 60 + 20 = 80 lin. ft.
∴ No. piles = 80 ft. ÷ 11 in. = 88 No.
∴ Lin. ft. piles total = 88 × 15 = 1,320 lin. ft.
∴ „ „ driven = 88 × 6 = 528 „

∴ *Cost of Works*

Handle and pitch = 1,320 lin. ft. at 16·80 pence	£92 8 0
Drive = 528 „ „ 11·16 „	£24 11 0
Extras for corners 2 No. piles = 30 lin. ft. at 18·60 pence .	£2 6 6
	£119 5 6
Off-load, and re-load frame and allow level ground Set up and dismantle. Labour 600 hours at 2/- .	£60 0 0
∴ Labour and plant cost of works	£179 5 6

Note.—(1) If walings and struts fixed, this to be added to the cost. For labour rates fixing, see tables.
(2) In above case piles are assumed left in.
(3) Cost of piles to be added to the above and also haulage cost of plant.

Example No. 2

Adoption of Sheet Piling in Laying a Pipe across a Canal or River

This work has to be carried out in two stages. Two rows of piles are driven (of sufficient width apart to form trench for pipe) half-way across canal and a bulkhead driven also, thus forming a coffer-dam as it were, half-way across. The muck is then excavated and pipes laid and trench refilled and a bulkhead fixed across pipe, and made watertight. This can be of timber suitably puddled so as to exclude water. The original bulkhead is then removed and the piling driven for the second half, which is then completed in the same way. The usual method of carrying the piling frame out across the canal, if fairly wide and deep, is by driving 9 in. × 9 in. timber staging piles in the canal bed, using "skeleton leaders".on a crane's jib in lieu of a frame and erecting a gantry out into the river with timber baulks on which to run the frame, these staging piles being removed on completion. If the canal is not very wide and not very deep, it may be possible to rig up a gantry of R.S.J.'s or baulks supported on canal bank and bed, or alternatively drive all piles by crane, using a McKiernan Terry hammer.

Whichever method is adopted the cost of the erection and removal of any gantry platform on which to run the piling frame must be added.

Canal Crossing—Non-Tidal Water

Pile for the laying of a pipe across a canal 30 ft. wide, piles 3 ft. apart, using O.G.B. piles as before, 15 ft. long, driven 6 ft. into bed. Labour 2*s*. per hour, Carpenter 2*s*. 6*d*. per hour.

Piles driven 2 rows for first half and a 3 ft. bulkhead = 33 lin. ft. and 2 corners.
„ „ 2 rows for second half = 30 „
∴ Total No. piles = 63 lin. ft. ÷ 11 in. = 69 No. at 15 ft.
= 1,035 lin. ft.
Length driven = 69 No. at 6 ft. = 414 „

Cost of Works. (See Method 1 for make-up of Handle and Drive Rates.)

∴ Handle and pitch. 1,035 lin. ft. at 16·80 pence .. .. =	£72	9	0
Drive. 414 „ „ 11·16 „ .. .. =	£19	5	0
Extras for corners. 30 „ „ 18·60 „ .. .. =	£2	6	6
Remove piles (from tables) 414 „ „ 22·36 „ .. .. =	£38	11	6
Fix walings, 12×6 in. (from tables), say 60 lin. ft. = 30 cu. ft. at 1/10 =	£2	15	0
„ struts, 6×6 in. (from tables), say 21 lin. ft. = 5·40 cu. ft. at 2/3 =	£0	12	2
	£135	19	2
Off-load and re-load frame and allow for gantry, say 600 hrs. at 2/-	£60	0	0
∴ Labour and plant cost of works	£195	19	2

Note.—In this case piles are recoverable, but it is usual to charge 25% of their cost to allow for wear and tear. Haulage cost of plant to be added to the above.

SECTION NINETEEN

★

PIPELAYER

In this section the laying and jointing of stoneware, concrete, cast iron and asbestos cement pipes is dealt with.

General.—In estimating the laying of pipes, the following must be considered:

(1) The off-loading of the pipes from the lorry in which they are delivered to the site must be allowed for, as must the handling of them to the side of the trenches in which they are to be laid.

(2) It should be noted that the greater the depth at which the pipes are laid below ground the greater the cost of laying.

(3) In tunnel work, the farther the pipes have to be hauled through, the greater the cost of laying.

(4) If pipes are delivered to the station only, nearest to the site, allowance must be made to haul from station to the site

The labour hours shown in the tables assume that the pipes are delivered to the site by lorry and allow for all off-loading, laying, jointing, and testing. If pipes have to be hauled from a station the haulage costs per lin. yd. of pipe, including off-loading from trucks, must be added at so much per lin. yd.

The Tables.—Tables shown are for laying only, and jointing only, and multipliers are shown for laying at various depths below ground and in tunnels.

Stoneware Pipes and Concrete Tubes

Table No. 1 shows the laying of the pipes only, while Tables 2 and 3 show the jointing only, the quantities of mortar and yarn per joint being given together with the jointer and labourer hours per joint. Both spigot and socket joints and ogee joints are shown. These are shown separately, as the length of pipes is variable, so by using the tables a price per lin. yd. can be got whether the pipe is 2 ft. long or 6 ft. long, as is generally the case with 4 in. stoneware pipes and large concrete tubes. The method of using these tables is to work out the cost of the joint from Tables 2 and 3, and divide this cost by the length of pipe in yards, adding to this the laying only cost per yard, giving the total cost per lin. yd., laid and jointed.

Example.—Calculate the cost to lay and joint per lin. yd. a 9 in. concrete pipe, 2 ft. 6 in. long.

From Table No. 2 Cost of Joint is :

Yarn	0·14 lb. at, say, 5*d.*	= 0·70 pence
Mortar	0·06 cu. ft. at, say, 2/-	= 1·44 „
Jointer hours	0·14 at, say, 2/3	= 3·78 „
Labourer hours	0·14 at, say, 2/-	= 3·36 „
Total cost of one joint		= 9·28

Pipe is 2 ft. 6 ins. long = $\frac{5}{6}$ lin. yds.

$\therefore$ Cost of joint per lin. yd. = $\frac{6}{5} \times \frac{9·28}{1}$ = 11·14 pence

From Table No. 1 *Cost of Laying is:*

Pipelayer .. .. 0·14 hours at 2/3 = 3·78 pence
Labourer .. .. 0·14 „ „ 2/- = 3·36 „

$\therefore$ Total cost lay joint and test .. .. = 18·28 pence per lin. yd

Multipliers

These are shown to cover:

1. Laying pipes at various depths below ground.
2. Laying pipes in tunnels up to 50 ft. long.
3. Laying pipes in tunnels over 50 ft. long and up to 250 ft. in length.

TABLE SHOWING CEMENT AND SAND PER CUBIC YARD OF MORTAR

Mix	*Cement tons*	*Sand cu. yds.*
1 to 1	0·79	0·73
1 to 1½	0·67	0·93
1 to 2	0·54	1·00
1 to 2½	0·46	1·07
1 to 3	0·39	1·10
1 to 3½	0·33	1·15
1 to 4	0·29	1·20

Note.—The data shown relating to sand refer to dry sand. If washed sand is used, a multiplier of 1·25 should be used in conjunction with the quantities of sand shown to allow for bulkage due to the moisture content.

For mixing cement mortar allow 7·00 labour hours per cu. yd.

TABLE No. 1

OFF-LOAD AND LAY ONLY STONEWARE PIPES OR CONCRETE TUBES PER LINEAL YARD

Labour hours per lin. yard	*Diameter of pipe in inches*											
	4	6	9	12	15	18	21	24	27	30	33	36
Pipelayer hours	0·07	0·10	0·14	0·16	0·17	0·20	0·22	0·25	0·29	0·34	0·40	0·50
Labourer hours	0·07	0·10	0·14	0·32	0·34	0·60	0·66	0·75	0·87	1·36	1·60	2·00

Note.—Labour hours shown in tables include for testing stoneware pipes and for knocking up the mortar for the joints.

If stoneware pipes are laid and jointed but *not* tested, as for surface water sewers, use a multiplier of 0·80 with the Pipelayer, Jointer and Labour hours shown for laying and jointing pipes.

MULTIPLIERS FOR USE WITH THE LAYING ONLY TABLE FOR PIPES LAID AT VARIOUS DEPTHS BELOW GROUND

Depth below ground	*Multipliers*
Average, 10 ft.	1·00
Depth not exceeding 15 ft.	1·30
„ „ „ 20 ft.	1·70

TABLE No. 2

MAKING ONLY CEMENT MORTAR JOINTS TO STONEWARE PIPES OR CONCRETE TUBES WITH SPIGOT AND SOCKET JOINTS, EACH

Item	*Unit*	*Diameter of pipe in inches*											
		4	6	9	12	15	18	21	24	27	30	33	36
Yarn per joint ..	lb.	0·03	0·06	0·14	0·30	0·38	0·44	0·76	0·87	0·97	1·42	1·78	2·14
Mortar per joint ..	cu. ft.	0·02	0·03	0·06	0·09	0·14	0·18	0·27	0·34	0·40	0·45	0·62	0·78
Jointer per joint ..	hours	0·10	0·12	0·14	0·16	0·18	0·20	0·27	0·33	0·40	0·48	0·57	0·70
Labourer per joint	„	0·10	0·12	0·14	0·16	0·36	0·40	0·54	0·66	0·80	0·96	1·14	1·40

TABLE No. 3

MAKING ONLY CEMENT MORTAR JOINTS TO CONCRETE TUBES WITH OGEE JOINTS EACH

Item	*Unit*	*Diameter of concrete tube in inches*										
		6	9	12	15	18	21	24	27	30	33	36
Mortar per joint ..	cu. ft.	0·01	0·02	0·04	0·06	0·08	0·10	0·17	0·22	0·25	0·27	0·30
Jointer „ „ ..	hours	0·10	0·12	0·14	0·16	0·18	0·24	0·29	0·36	0·44	0·52	0·66
Labourer „ „ ..	„	0·10	0·12	0·14	0·32	0·36	0·48	0·58	0·72	0·88	1·04	1·32

Note.—The hours shown in tables allow for knocking up the mortar for the joints.

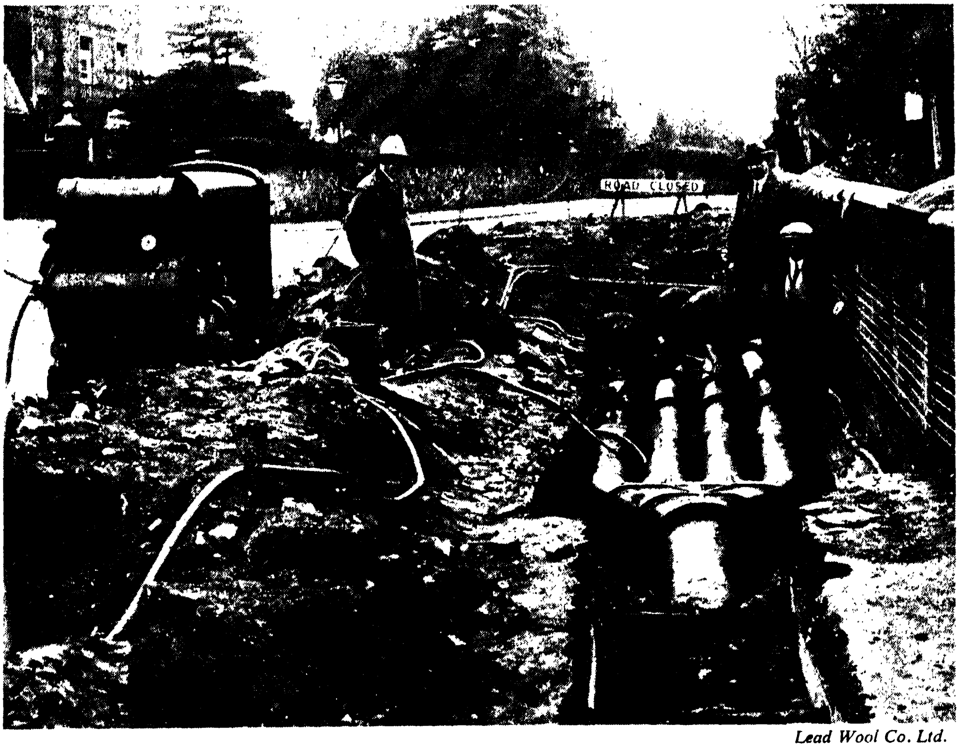


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FIG. 29.—PNEUMATIC TOOLS FOR PIPE JOINTING

MULTIPLIERS FOR USE WITH TABLES 1, 2, AND 3 FOR PIPES LAID IN TUNNELS OR HEADINGS UP TO 50 FEET LONG

Pipelayer, Jointer and Labourer Hour Multipliers	*Diameter of pipe in inches*											
	4	6	9	12	15	18	21	24	27	30	33	36
Multiplier	1·20	1·25	1·30	1·35	1·40	1·45	1·50	1·55	1·60	1·65	1·70	1·75

MULTIPLIERS FOR USE WITH THE ABOVE TABLE IN TUNNELS OVER 50 FT. LONG

Item	*Length through tunnel in feet*				
	0–50	0–100	0–150	0–200	0–250
Multiplier	1·00	1·10	1·20	1·30	1·40

Note.—The data shown is applicable to pipes laid and jointed in tunnels to 50 ft. below ground level.

STONEWARE—SUNDRY WORKS

Item	*Unit*	*Bricklayer or Pipelayer hours*	*Labourer hours*
Bends stoneware, fixed. 4 in. extra on	each	0·05	0·05
„ „ „ 6 in. „	„	0·10	0·10
„ „ „ 9 in. „	„	0·15	0·15
„ „ „ 12 in. „	„	0·20	0·20
Channels, stoneware, straight, fixed. 4 in.	lin. ft.	0·08	0·08
„ „ „ „ 6 in.	„	0·12	0·12
„ „ „ „ 9 in.	„	0·16	0·16
„ „ „ „ 12 in.	„	0·20	0·20
Channel bends or junctions, fixed. 4 in.	„	0·16	0·16
„ „ „ „ 6 in.	„	0·20	0·20
„ „ „ „ 9 in.	„	0·26	0·26
„ „ „ „ 12 in.	„	0·33	0·33
Channels tapered. Largest dia. 4 in.	„	0·13	0·13
„ „ „ „ 6 in.	„	0·17	0·17
„ „ „ „ 9 in.	„	0·22	0·22
„ „ „ „ 12 in.	„	0·30	0·30
Grease traps, fixed	each	0·75	0·75
Gullies, 12 in. dia. by 2 ft. 6 in. deep. Fix pots only*	„	nil	1·30
„ 15 in. dia. by 3 ft. deep. „ „ *	„	nil	1·50
„ 18 in. dia. by 3 ft. 6 in. deep. „ „ *	„	nil	1·70
„ 18 in. dia. by 4 ft. deep. „ „ *	„	nil	1·80
„ yard type	„	0·50	0·50
Gratings fixed to gullies	per cwt.	0·70	0·70
Stoneware, junctions fixed. 4 in. extra on	each	0·08	0·08
„ „ „ 6 in. „	„	0·15	0·15
„ „ „ 9 in. „	„	0·25	0·25
„ „ „ 12 in. „	„	0·33	0·33
Rainwater shoes fixed	„	0·40	0·40
Saddles fixed. 4 in.	„	0·75	0·75
„ „ 6 in.	„	1·00	1·00
„ „ 9 in.	„	1·25	1·25
„ „ 12 in.	„	1·50	1·50
Taper pipes. Largest dia. 4 in. extra on	„	0·04	0·04
„ „ „ „ 6 in. „	„	0·08	0·08
„ „ „ „ 9 in. „	„	0·12	0·12
„ „ „ „ 12 in. „	„	0·16	0·16

* *Note.*—Gullies, Road Type. For excavating for, etc., see under Roadmaker Section, page 257.

Cast Iron Pipes

Cast iron pipes are made in various standard lengths. Tables are therefore shown for the laying only of the pipes, and separate tables for making the joints.

This is necessary as the variation in lengths of the pipes makes it impossible to estimate a cost per lin. yd. laid and jointed unless the cost of the joint itself is known. The method of using the tables to calculate the cost of one lin. yd. of pipe, laid and jointed, is as follows:

(1) Calculate the cost of one joint using the relevant jointing table (pages 224-227).

(2) Divide this cost by the length of the pipe in yards, this giving the cost of jointing per lin. yd. of pipe.

(3) Using the laying only tables (page 224), calculate the cost of laying only the pipe. The sum of these two costs is the cost per lin yd. laid and jointed.

Example. Calculate the cost per lin. yd to lay and joint, with run lead joints, 6 in. dia. cast iron pipes 18 ft. long each. Class B Pipes.

From Table on page 225 Cost of One Joint is:

Yarn	0·70 lb. at, say, 5*d.* lb.	= 3·50 pence
Lead	6·8 ,, ,, 3*d.* lb.	= 20·40 ,,
Jointer hours	0·76 ,, ,, 2/3	= 20·52 ,,
Labourer hours	0·38 ,, ,, 2/-	= 9·12 ,,
Add for coke, say		= 2·46 ,,
∴ Total cost of 1 joint		= 56·00 ,,

Pipe is 6 yds. long. ∴ Cost of joint per lin. yd. = $\frac{56}{6}$ = 9·33 pence

From Table on page 224 Cost of Laying is:

Pipelayer hours	0·10 at 2/3	= 2·70 pence
Labourer hours	0·30 at 2/-	= 7·20 ,,
∴ Total cost lay and joint per lin. yd.		= 19·23

Material in Joints

It should be noted that the weights of yarn and lead per joint shown in the tables may vary. The weights to be used are usually specified for the contract to be tendered for, and these must be used in preparing the estimate. The lead and yarn per joint, as shown, are, however, fair average quantities as often used. Joints of various types are shown, such as run lead, lead wool single collar, and lead wool double collar, knocked up both by hand and pneumatic tools. The latter method is used on diameters 9 in. and over, where the rate of laying is fast, such as in cross-country pipelines, and it has in fact to be used to keep up with the laying rate. This can be appreciated when it is known that two men in a 10 hour day can only knock up four No. 48 in. joints, whereas two men with pneumatic caulkers can comfortably do eight joints in the same time.

Cast Iron Specials

The labour shown for work in connection with specials gives the actual cost of off-loading and placing them in the work and also the extra lead joint involved.

These specials are usually billed in the bill of quantities as "Extra on Straight Pipes", and if this is so the constants shown hold good, but from them, when extended, must be subtracted the cost of a length of pipe equal to the length of the special.

Example: *Extra only over Straight Pipe Supply and Lay* 9 *in. Bend, each*

Length of 9 in. bend is 3 ft.

Material cost of 9 in. bend, say	=	53/-
Cost of 1 yd. of straight 9 in. pipe, say	=	16/-
∴ The extra on material cost	=	37/-
Lead in joint, 13 lb. at 3*d.*	=	3/3
Yarn in joint, 1 lb. at 5*d.*	=	-/5
Pipelayer hours, 1·00 at 2/3	=	2/3
Pipe jointer hours, 1·00 at 2/3	=	2/3
Labourer hours, 3·00 at 2/-	=	6/-
∴ The extra on cost of bend	=	51/2 each

Classes of Cast Iron Pipes

There are four classes of pipes made, viz.:

Class A. The lightest in weight per lin. yd.—usually used for gas.
Class B. Tested to 400 ft. head—used for water mains.
Class C. Tested to 600 ft. head—used for water mains.
Class D. Tested to 800 ft. head—used for water mains.

The tables on page 224 allow for the variation in weight.

STANDARD WEIGHT OF SPUN IRON SPIGOT AND SOCKET PIPES--PER PIPE

Pipes 4 *yards long, and* (*lower table*), *pipes* 6 *yards long*

Dia. of pipe in inches	*Class B*			*Class C*			*Class D*		
	cwts.	*qrs.*	*lb.*	*cwts.*	*qrs.*	*lb.*	*cwts.*	*qrs.*	*lb.*
3	1	1	2	1	1	2	1	1	6
4	1	2	7	1	2	14	1	3	0
5	2	0	7	2	1	0	2	2	0
6	2	2	14	2	3	21	3	1	7
7	3	0	7	3	2	0	3	3	21
8	3	2	21	4	1	7	4	3	7
9	4	1	7	5	0	14	5	3	7
12	6	1	4	7	3	7	8	3	7
15	8	3	0	10	3	7	12	1	0
18	11	1	21	14	0	21	16	0	14

Dia. of pipe in inches	*Class B*			*Class C*			*Class D*		
	cwts.	*qrs.*	*lb.*	*cwts.*	*qrs.*	*lb.*	*cwts.*	*qrs.*	*lb.*
4	2	1	3	2	1	13	2	2	6
5	2	3	26	3	1	2	3	2	16
6	3	3	6	4	1	3	4	3	10
7	4	1	21	5	0	10	5	3	0
8	5	1	8	6	1	1	7	0	0
9	6	0	24	7	1	21	8	1	24
12	9	0	24	11	1	12	12	3	14
15	12	2	13	15	2	22	17	3	11
18	16	2	3	20	2	13	23	2	2

STANDARD WEIGHT OF CAST IRON SPIGOT AND SOCKET VERTICALLY CAST PIPES—PER PIPE

Dia. of pipe in inches	*Class A*			*Class B*			*Class C*			*Class D*		
	Weight of 4 yd. pipe			*Weight of 4 yd. pipe*			*Weight of 4 yd. pipe*			*Weight of 4 yd. pipe*		
	cwts.	*qrs.*	*lb.*	*cwts.*	*qrs.*	*lb.*	*cwts.*	*qrs.*	*lb.*	*cwts.*	*qrs.*	*lb.*
4	1	3	25	1	3	25	2	0	2	2	1	1
5	2	2	6	2	2	6	2	3	2	3	0	13
6	3	0	21	3	0	21	3	2	7	4	0	5
7	3	3	13	3	3	13	4	1	22	5	0	2
8	4	2	16	4	2	16	5	1	26	6	0	15
9	5	1	17	5	1	17	6	1	21	7	1	1
12	7	3	8	8	0	8	10	0	5	11	1	19
15	10	2	3	11	0	16	13	3	23	15	3	9
18	13	1	21	14	2	5	18	1	12	20	3	4

WEIGHT OF BARREL OF CAST IRON PIPES IN CWTS. PER LINEAL YARD

Dia. of pipe in inches	*Class A pipes*	*Class B pipes*	*Class C pipes*	*Class D pipes*
3	0·38	0·38	0·38	0·40
4	0·49	0·49	0·50	0·57
5	0·64	0·64	0·69	0·78
6	0·80	0·80	0·89	1·00
7	0·97	0·97	1·10	1·26
8	1·16	1·16	1·37	1·53
9	1·35	1·35	1·60	1·82
12	1·96	2·02	2·50	2·86
15	2·63	2·79	3·49	3·96
18	3·36	3·64	4·59	5·20

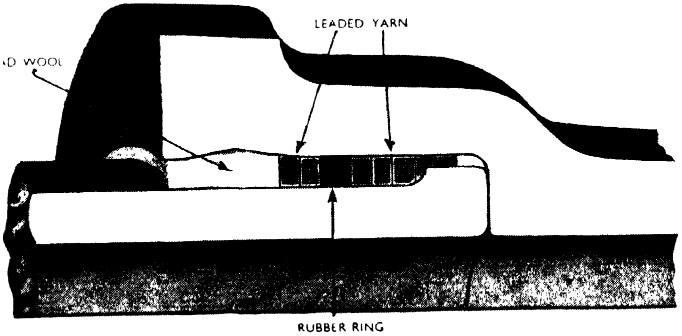

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FIG. 30.—A FLEXIBLE JOINT FOR ORDINARY SPIGOT AND SOCKET PIPES

OFF-LOAD AND LAY ONLY CAST IRON PIPES (TO B.S. 78:1938) PER LINEAL YARD

Dia. of pipe in inches	*Class A Pipes*		*Class B Pipes*		*Class C Pipes*		*Class D Pipes*	
	Pipelayer hours lin. yd.	*Labourer hours lin. yd.*	*Pipelayer hours lin. yd.*	*Labourer hours lin. yd.*	*Pipelayer hours lin. yd.*	*Labourer hours lin. yd.*	*Pipelayer hours lin. yd.*	*Labourer hours lin. yd.*
3	0·07	0·14	0·07	0·14	0·07	0·14	0·07	0·14
4	0·08	0·16	0·08	0·16	0·08	0·16	0·08	0·16
5	0·09	0·18	0·09	0·18	0·09	0·18	0·10	0·20
6	0·10	0·30	0·10	0·30	0·10	0·30	0·11	0·33
7	0·11	0·33	0·11	0·33	0·11	0·33	0·12	0·36
8	0·12	0·36	0·12	0·36	0·13	0·39	0·14	0·42
9	0·13	0·39	0·13	0·39	0·15	0·45	0·16	0·48
12	0·18	0·72	0·18	0·72	0·21	0·84	0·23	0·92
15	0·22	0·88	0·23	0·92	0·27	1·08	0·29	1·16
18	0·27	1·08	0·28	1·12	0·34	1·36	0·37	1·48
21	0·32	1·28	0·34	1·36	0·40	1·60	0·45	1·80
24	0·37	1·48	0·40	1·60	0·46	1·84	0·52	2·08
27	0·43	1·72	0·47	1·88	0·53	2·12	0·58	2·32
30	0·49	2·45	0·54	2·70	0·58	2·90	0·64	3·20
33	0·54	2·70	0·60	3·00	0·64	3·20	0·71	3·55
36	0·60	3·00	0·66	3·30	0·70	3·50	0·78	3·90
42	0·70	4·20	0·74	4·44	0·80	4·80	0·90	5·40
48	0·75	4·50	0·80	4·80	0·90	5·40	1·04	6·24

Note.—(1) Labour hours shown include for testing.
(2) For pipes with turned and bored joints use the above tables with a multiplier of 1·25.

OFF-LOAD AND LAY ONLY SPUN IRON PIPES PER LINEAL YARD

Dia. of pipe in inches	*Class B pipes*		*Class C pipes*		*Class D pipes*	
	Pipelayer hours lin. yd.	*Labourer hours lin. yd.*	*Pipelayer hours lin. yd.*	*Labourer hours lin. yd.*	*Pipelayer hours lin. yd.*	*Labourer hours lin. yd.*
3	0·06	0·12	0·06	0·12	0·06	0·12
4	0·07	0·14	0·07	0·14	0·07	0·14
5	0·08	0·16	0·08	0·16	0·09	0·18
6	0·09	0·27	0·09	0·27	0·10	0·30
7	0·10	0·30	0·10	0·30	0·11	0·33
8	0·11	0·33	0·11	0·33	0·12	0·36
9	0·12	0·36	0·13	0·39	0·14	0·42
12	0·16	0·64	0·18	0·72	0·20	0·80
15	0·20	0·80	0·23	0·92	0·25	1·00
18	0·24	0·96	0·29	1·16	0·32	1·28
21	0·29	1·16	0·34	1·36	0·39	1·56
24	0·34	1·36	0·39	1·56	0·45	1·80

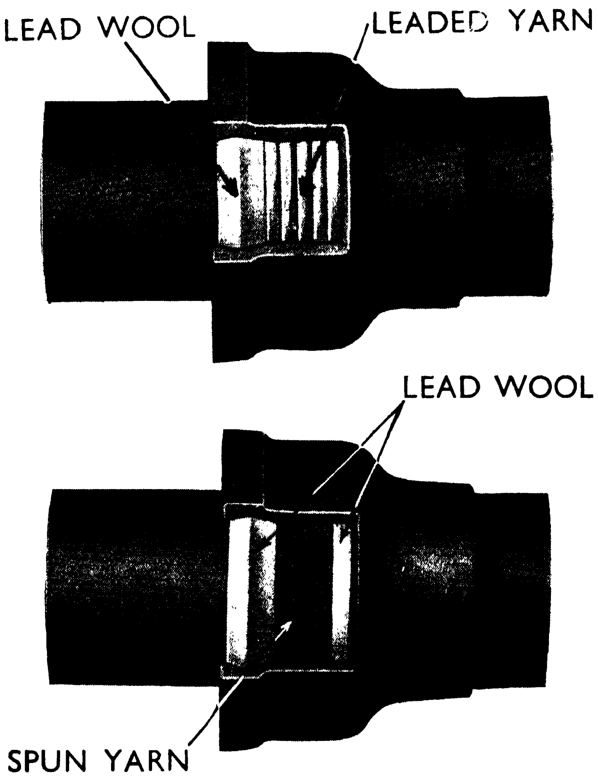
MULTIPLIERS FOR USE WITH THE LAYING ONLY TABLES FOR PIPES LAID AT VARIOUS DEPTHS BELOW GROUND

Depth below ground	*Multipliers*
Average 5 ft.	1·00
Depth not exceeding 10 ft.	1·40
„ „ „ 15 ft.	1·90
„ „ „ 20 ft.	2·50

JOINTING ONLY CAST IRON PIPES WITH RUN LEAD JOINTS KNOCKED UP BY HAND—EACH

Dia. of pipe in inches	*Yarn per joint lb.*	*Lead per joint lb.*	*Jointer hours*	*Labourer hours*
3	0·25	3·75	0·40	0·20
4	0·35	4·50	0·52	0·26
5	0·60	6·00	0·64	0·32
6	0·70	6·80	0·76	0·38
7	0·80	8·50	0·88	0·44
8	0·93	11·00	1·00	0·50
9	1·00	13·00	1·12	0·56
12	1·40	15·00	1·70	0·57
15	1·90	22·00	2·10	0·70
18	2·07	31·50	2·61	0·87
21	3·00	36·00	3·10	1·03
24	4·40	40·00	3·60	1·20
27	5·00	45·00	4·10	1·37
30	5·50	51·00	4·60	1·54
33	6·00	56·00	5·10	1·70
36	6·60	62·00	5·60	1·87
42	7·60	70·00	6·60	2·20
48	8·80	81·00	7·60	2·54

Note.—Weights of lead and yarn per joint may be specified to be other than those shown, in which case substitute the particular weight specified.



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FIGS. 31–32. — THE ILLUSTRATIONS ABOVE SHOW A LEAD WOOL AND LEADED YARN JOINT, AND A LEAD WOOL AND SPUN YARN JOINT

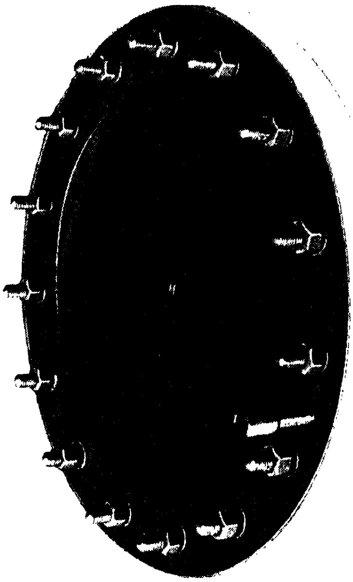

FIG. 33.—SPIGOT-END PLUG

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JOINTING ONLY CAST IRON PIPES WITH RUN LEAD JOINTS. KNOCKED UP BY PNEUMATIC TOOLS—EACH

Dia. of pipe in inches	*Yarn per joint lb.*	*Lead per joint lb.*	*Jointer hours*	*Labourer hours*	*2-tool compressor hours*
12	1·40	15·00	0·60	0·20	0·30
15	1·90	22·00	0·76	0·25	0·38
18	2·07	31·50	0·92	0·31	0·46
21	3·00	36·00	1·08	0·36	0·54
24	4·40	40·00	1·24	0·41	0·62
27	5·00	45·00	1·40	0·46	0·70
30	5·50	51·00	1·56	0·52	0·78
33	6·00	56·00	1·72	0·57	0·86
36	6·60	62·00	1·86	0·62	0·93
42	7·60	70·00	2·18	0·73	1·09
48	8·80	84·00	2·50	0·84	1·25

Note.—(1) Table allows for compressor taking 2 tools.

(2) Weights of lead and yarn per joint may be specified in the contract being tendered for. If different from those shown in table substitute the specified weights.

JOINTING ONLY CAST IRON PIPES WITH LEAD WOOL JOINTS SINGLE COLLAR TYPE—EACH

Nominal internal Dia. of pipe	*Material for single collar joint*					*Joints knocked up by hand*		*Joints knocked up pneumatically*		
	"Lead wool"			*Yarn*		*Jointer hours*	*Labourer hours*	*Jointer hours*	*Labourer hours*	*2-tool compressor hours*
	Depth	*Weight*	*No. of skeins*	*Depth*	*Weight*					
inches	*inches*	*lb. oz.*		*inches*	*lb. oz.*					
3	1⅛	2 10	2½	1⅞	4	0·34	0·17	—	—	—
4	1¼	3 12	3½	1¾	5	0·44	0·22	—	—	—
5	1¼	4 4	4	2¼	7	0·56	0·28	—	—	—
6	1⅜	5 5	5	2⅛	8	0·66	0·33	—	—	—
7	1⅜	6 6	6	2⅛	9	0·78	0·39	—	—	—
8	1⅜	7 7	7	2⅝	14	0·90	0·45	—	—	—
9	1⅜	8 0	7½	2⅝	1 0	1·00	0·50	0·60	0·30	0·30
10	1⅜	9 1	8½	2⅝	1 3	1·10	0·55	0·64	0·32	0·32
12	1⅜	10 10	10	2⅝	1 5	1·30	0·65	0·70	0·35	0·35
14	1½	13 5	12½	3	1 15	1·50	0·75	0·84	0·42	0·42
15	1½	14 6	13½	3	2 1	1·60	0·80	0·90	0·45	0·45
16	1½	15 7	14½	3	2 3	1·70	0·85	1·04	0·52	0·52
18	1⅝	21 4	20	2⅞	2 15	1·80	0·90	1·33	0·66	0·66
20	1⅝	23 15	22½	2⅞	3 4	2·20	1·10	1·50	0·75	0·75
24	1⅝	28 3	26½	3⅜	4 14	2·70	1·35	1·85	0·92	0·92
30	1⅝	34 9	32½	3⅜	6 0	3·40	1·70	2·30	1·15	1·15
33	1⅝	37 12	35½	3⅜	6 11	3·70	1·85	2·50	1·25	1·25
36	1⅝	41 7	39	3⅜	7 5	4·00	2·00	2·70	1·35	1·35
48	1⅞	62 11	59	3⅝	10 8	5·60	2·80	4·10	2·05	2·05

Note.—Table allows for compressor taking two tools.

JOINTING ONLY CAST IRON PIPES WITH LEAD WOOL JOINTS DOUBLE COLLAR TYPE—EACH

Nom'l Internal Dia. of Pipes	*Material for double collar joint*								*Joints knocked up by hand*		*Joints knocked up pneumatically*		
	"Lead wool" back of socket			*Yarn for intermediate*		*"Lead wool" front of socket*							
	D'pth	*Weight*	*No. of skeins*	*Depth*	*Weight*	*Depth*	*Weight*	*No. of skeins*	*Jointer hours*	*Lab. hours*	*Jointer hours*	*Lab. hours*	*2-tool compres'r hours*
ins.	*ins.*	*lb. oz.*		*ins.*	*lb. oz.*	*ins.*	*lb. oz.*						
3	¾	1 10	1½	1½	2½	¾	1 10	1½	0·40	0·20	—	—	—
4	⅝	1 10	1½	1⅛	2½	1¼	3 12	3½	0·52	0·26	—	—	—
5	½	1 10	1½	1¾	4½	1¼	4 4	4	0·66	0·33	—	—	—
6	⅜	1 10	1½	1¾	6	1⅜	5 5	5	0·78	0·39	—	—	—
7	½	2 10	2½	1¾	6½	1¼	5 14	5½	0·90	0·45	—	—	—
8	¾	3 3	3	1⅞	8½	1⅜	7 7	7	1·04	0·52	—	—	—
9	½	3 3	3	2⅛	11½	1⅜	8 0	7½	1·18	0·59	0·80	0·40	0·40
10	½	3 12	3½	2⅛	13½	1⅜	9 !	8½	1·28	0·64	0·86	0·43	0·43
12	⅝	4 13	4½	2	14	1⅜	10 10	10	1·48	0·74	0·94	0·47	0·47
14	¾	6 6	6	2¼	1 5	1½	13 5	12½	1·70	0·85	1·10	0·55	0·55
15	¾	7 7	7	2¼	1 6	1½	14 6	13½	1·80	0·90	1·20	0·60	0·60
16	¾	8 1	7½	2¼	1 8	1½	15 7	14½	1·90	0·95	1·40	0·70	0·70
18	¾	9 9	9	2⅛	1 15	1⅝	21 4	20	2·10	1·05	1·80	0·90	0·90
20	¾	11 3	10½	2⅛	2 1	1⅝	23 15	22	2·46	1·23	2·00	1·00	1·00
24	¾	13 5	12½	2⅝	3 7	1⅝	28 3	26	3·16	1·58	2·48	1·24	1·24
30	¾	15 15	15	2⅝	4 6	1⅝	34 9	32½	4·00	2·00	3·06	1·43	1·53
33	¾	17 9	16½	2⅝	4 12	1⅝	37 12	35½	4·34	2·17	3·34	1·67	1·67
36	¾	19 2	18	2⅝	5 4	1⅝	41 7	39	4·70	2·35	3·60	1·80	1·80
48	1	33 8	31½	2⅝	7 0	1⅞	62 11	59	6·60	3·30	5·50	2·75	2·75

Note.—Table allows for Compressor taking two tools.

Off-load, Lay and Joint, Cast Iron Specials, Each

BENDS

Diameter	3 *ins.*	4 *ins.*	5 *ins.*	6 *ins.*	7 *ins.*	8 *ins.*	9 *ins.*	12 *ins.*
Lead in joints, lb. . .	3·75	4·50	6·00	6·80	8·50	11·00	13·00	15·00
Yarn „ „ „ . .	0·25	0·35	0·60	0·70	0·80	0·93	1·00	1·40
Pipelayer hours . .	0·40	0·50	0·60	0·70	0·80	0·90	1·00	1·30
Pipe jointer „ . .	0·40	0·50	0·60	0·70	0·80	0·90	1·00	1·30
Labourer „ . .	1·20	1·50	1·80	2·10	2·40	2·70	3·00	3·90

TEES AND ANGLE BRANCHES

Branches on pipes whose diameter is	3 *ins.*	4 *ins.*	5 *ins.*	6 *ins.*	7 *ins.*	8 *ins.*	9 *ins.*	12 *ins.*
Lead in joints, lb. . .	3·75	4·50	6·00	6·80	8·50	11·00	13·00	15·00
Yarn „ „ „ . .	0·25	0·35	0·60	0·70	0·80	0·93	1·00	1·40
Pipelayer hours . .	0·50	0·60	0·70	0·80	0·90	1·00	1·10	1·40
Jointer „ . .	0·50	0·60	0·70	0·80	0·90	1·00	1·10	1·40
Labourer „ . .	1·50	1·80	2·10	2·40	2·70	3·00	3·30	4·20

TAPERS

Diameters	3 *to* 4 *ins.*	4 *to* 5 *ins.*	5 *to* 6 *ins.*	6 *to* 7 *ins.*	7 *to* 8 *ins.*	8 *to* 9 *ins.*	9 *to* 12 *ins.*
Lead in joints, lb.	4·50	6·00	6·80	8·50	11·80	13·00	15·00
Yarn „ „ „	0·35	0·60	0·70	0·80	0·93	1·00	1·40
Pipelayer hours	0·40	0·50	0·60	0·70	0·80	0·90	1·00
Jointer „	0·40	0·50	0·60	0·70	0·80	0·90	1·00
Labourer „	1·20	1·50	1·80	2·10	2·40	2·70	3·00

MULTIPLIERS FOR USE WITH TABLES ON PAGES 224–7 FOR LAYING AND JOINTING CAST IRON PIPES IN TUNNELS UP TO 50 FT. LONG

Dia. of pipe in inches	*Multipliers*	*Dia. of pipe in inches*	*Multipliers*
3	1·20	18	1·36
4	1·21	21	1·40
[illegible]	1·22	24	1·45
6	1·23	27	1·50
7	1·24	30	1·56
8	1·25	33	1·62
9	1·26	36	1·67
12	1·29	42	1·82
15	1·32	48	2·02

MULTIPLIERS FOR TUNNELS IN EXCESS OF 50 FT. LENGTH

Length of tunnel in feet	0–50	0–100	0–150	0–200	0–250
Multiplier	1·00	1·10	1·20	1·30	1·40

Note.—The data shown are applicable to pipes laid and jointed in tunnels to 50 ft. below ground level.

CAST IRON PIPES—SUNDRY WORKS

Description	*Unit*	*Pipelayer, Jointer, or Bricklayer hours*	*Labourer hours*
Fix air valves, tapped and screwed	each	1·50	1·50
„ „ „ single acting—flanged	„	1·00	1·00
„ „ „ double acting—flanged	„	1·25	1·25
Fix air valve covers	„	0·75	0·75
„ hydrants—ball type	„	0·75	0·75
„ „ screwdown type	„	1·25	1·25
„ hydrant covers	„	0·80	0·80
„ sluice valves, 3 in. dia.	„	1·50	—
„ „ „ 4 in. dia.	„	2·00	—
„ „ „ 5 in. dia.	„	2·50	—
„ „ „ 6 in. dia.	„	3·00	—
„ „ „ 7 in. dia.	„	3·50	—
„ „ „ 8 in. dia.	„	4·00	—
„ „ „ 9 in. dia.	„	4·50	—
„ „ „ 10 in. dia.	„	5·00	—
„ „ „ 11 in. dia.	„	5·50	—
„ „ „ 12 in. dia.	„	6·00	—
„ sluice valve covers, heavy type	„	0·75	0·75
„ stop cock covers, 6 in. by 6 in.	„	0·25	0·25

CUTTING CAST IRON PIPES

Dia. in inches	*Unit*	*Pipelayer hours*	*Dia. in inches*	*Unit*	*Pipelayer hours*
3	each	0·50	18	each	4·20
4	,,	0·55	21	,,	5·50
5	,,	0·60	24	,,	7·00
6	,,	0·65	27	,,	8·70
7	,,	0·70	30	,,	10·60
8	,,	1·00	33	,,	12·70
9	,,	1·50	36	,,	15·00
12	,,	2·20	42	,,	20·20
15	,,	3·10	48	,,	26·20

Asbestos Cement Pipes

These pipes are now largely used for water distribution. They are generally 3 and 4 metres long and are lighter and easier to handle than cast iron pipes. The joints simply consist of rubber rings which slip over the two spigots of the pipes and a detachable iron band is placed over the rubber ring and bolted up. Easy to lay and joint, they show a saving in cost as compared with cast iron pipes.

The price of the joints is generally allowed for by the suppliers in the lin. yd. price when they quote, but care must be taken to see that this *is* the case, as sometimes they are quoted separately, in which case, knowing the length of pipe in metres (or yards), the cost of the joint per lin. yd. can be found.

OFF-LOAD AND LAY ONLY ASBESTOS CEMENT PIPES PER LINEAL YARD

Note.—Labour hours shown include for testing.

Diameter	3 *ins.*	4 *ins.*	5 *ins.*	6 *ins.*	7 *ins.*	8 *ins.*	9 *ins.*	10 *ins.*	12 *ins.*
Pipelayer hours	0·06	0·07	0·08	0·09	0·10	0·11	0·12	0·13	0·15
Labourer hours	0·12	0·14	0·16	0·27	0·30	0·33	0·36	0·52	0·60

CUTTING ASBESTOS PIPES

Dia. of pipe in inches	*Pipelayer hours*
3	0·25
4	0·33
5	0·41
6	0·49
7	0·57
8	0·65
9	0·73
10	0·81
12	1·00

TABLE OF MULTIPLIERS FOR USE WITH THE LAYING ONLY TABLE FOR PIPES LAID AT VARIOUS DEPTHS BELOW GROUND

Depth below ground	*Pipelayer and labourer hours Multipliers*
Average depth not exceeding 5 ft.	1·00
,, ,, ,, ,, 10 ft.	1·20
,, ,, ,, ,, 15 ft.	1·50
,, ,, ,, ,, 20 ft.	1·90

JOINTING ASBESTOS CEMENT PIPES PER JOINT

Diameter	3 *ins.*	4 *ins.*	5 *ins.*	6 *ins.*	7 *ins.*	8 *ins.*	9 *ins.*	10 *ins.*	12 *ins.*
Jointer hours	0·26	0·30	0·35	0·39	0·43	0·48	0·52	0·57	0·65
Labourer hours	0·26	0·30	0·35	0·39	0·43	0·48	0·52	0·57	0·65

SUNDRY WORKS IN CONNECTION WITH SEWAGE DISPOSAL WORKS

Description	*Unit*	*Brick-layer hours*	*Pipe-layer hours*	*Jointer hours*	*Labourer hours*
Ashes or clinker in beds	cu. yd.	—	—	—	2·00
Banks—dig and place muck in	”	—	—	—	2·60
„ trim slopes	sq. yd.	—	—	—	0·14
„ 4 in. soil slopes	”	—	—	—	0·30
„ sow grass seed	”	—	—	—	0·02
Brickwork—E.O. brick on edge coping, 9 in. . .	lin. ft.	0·10	—	—	0·10
” ” ” ” ” 14 in. . .	”	0·15	—	—	0·15
” ” ” ” ” 18 in. . .	”	0·20	—	—	0·20
„ E.O. oversailing per course	”	0·06	—	—	0·06
„ Horizontal chases cut up to 6 in. wide	”	0·40	—	—	0·40
„ Vertical „ „ „ 6 in. „	”	0·60	—	—	0·60
Concrete—rub down faces	sq. yd.	—	—	—	0·60
Channels, stoneware, 4 in. laid	lin. ft.	—	0·08	—	0·08
” ” 6 in. „	”	—	0·12	—	0·12
” ” 9 in. „	”	—	0·16	—	0·16
Dosing syphons, fixed	each	—	3·60	—	3·60
Feed pipes, 3 in. cast iron laid and jointed	lin. ft.	—	0·30	0·30	0·30
” ” 4 in. ” ” ” ”	”	—	0·35	0·35	0·35
” ” 6 in. ” ” ” ”	”	—	0·40	0·40	0·40
Flanged specials, 3 in. laid and jointed	”	—	0·60	0·60	0·60
” ” 4 in. ” ”	”	—	0·70	0·70	0·70
” ” 6 in. ” ”	”	—	0·80	0·80	0·80
„ or socket and spigot, 3 in. bends, fixed . .	each	—	1·40	1·40	1·40
” ” ” ” 4 in. ” ” . .	”	—	1·5	1·5	1·5
” ” ” ” 6 in. ” ” . .	”	—	1·6	1·6	1·6
” ” ” ” 3/3 tees, fixed . .	”	—	1·50	1·50	1·50
” ” ” ” 4/4 ” ” . .	”	—	1·60	1·60	1·60
” ” ” ” 6/6 ” ” . .	”	—	1·70	1·70	1·70
Handstops, fixed	sq. ft.	1·10	—	—	1·10
Holderbats „	each	0·60	—	—	0·60
Manhole covers fixed up to 5 cwts.	cwt.	0·50	—	—	0·50
Media placed	cu. yd.	—	—	—	2·00
Penstocks or disc valves, with 3 in. fixed spindles . .	each	-	3·30	3·30	—
” ” ” ” 4 in. ” ” . .	”	—	4·20	4·20	—
” ” ” ” 6 in. ” ” . .	”	—	5·10	5·10	—
Ragbolts, fixed	”	0·60	—	—	—
Screens, wrought iron, fixed	sq. ft.	0·70	—	—	0·70
Scum boards, fixed	”	0·60	—	—	0·60
” ” brackets, fixed	each	2·50	—	—	2·50
Sludge pipes, 3 in. cast iron, laid and jointed . .	lin. ft.	—	0·30	0·30	0·30
” ” 4 in. ” ” ” ” . .	”	—	0·35	0·35	0·35
” ” 6 in. ” ” ” ” . .	”	—	0·40	0·40	0·40
Sluice valves, 3 in. dia., fixed	each	—	nil	1·50	—
” ” 4 in. ” ”	”	—	nil	2·00	—
” ” 6 in. ” ”	”	—	nil	3·00	—
Washout pipes, 3 in. cast iron, laid and jointed . .	lin. ft.	—	0·25	0·25	0·25
” ” 4 in. ” ” ” ” . .	”	—	0·30	0·30	0·30
” ” 6 in. ” ” ” ” . .	”	—	0·35	0·35	0·35

It should be noted that due to cast iron pipe work being in short lengths, the cost of laying these in sewage disposal works is more expensive than in laying in long lengths. The constants shown make allowance for this.

SECTION TWENTY

★

PLANT: WORKING COST PER HOUR

Plant is one of the contractor's biggest items, both as regards capital outlay and the money laid out annually on its maintenance. Nowadays, in order to compete, the necessity of having modern, up-to-date plant is essential, and, as more new types of plant are continually coming on the market, this becomes more true as time goes on. It is therefore sound policy when buying new plant to buy a good article, and having bought it, to see that it is well cared for. This means a good plant engineer in charge of all upkeep, and also a good operator, interested in his plant, who will drive it carefully and attend to all oiling and greasing, etc., regularly. It is a fact that a good plant driver is well worth a good wage as he can save the owner of the plant many pounds in repairs and renewal costs.

The working life of different plant varies. A steam-roller, for example, may last for ten years, while a lorry may be worn out in two years. The average capital depreciation of the roller is therefore only 10%, while the lorry's is 50%. The number of hours per annum the plant works is another factor governing its life, so both the above have to be considered when calculating the "Working Cost per Hour".

So far as the contractor is concerned, he usually buys his plant and works it until it is done. It is bad business to buy plant and then sell second-hand, as the depreciation value is very large and were he to sell he would in all probability lose heavily on the transaction. If he had no contract on which to place any special item of plant, his policy should be:

(1) To take the opportunity to service and overhaul the machine should this be necessary, or (2) Hire it out preferably with its own driver.

It has been the experience of the writer that plant hired out without its own driver usually returns to the depot in bad condition, and has to have a considerable amount spent on it to make it serviceable again.

Plant can be hired and there are plant-hire firms throughout the country, but their charges per hour are naturally in excess of what the contractor could run his own plant at, since they have to make a living out of it. In connection with hiring plant, there is a point to note—the estimator would, under such circumstances, have to base his tender on the hire rates, since he would have to pay those rates.

Others competing against him might be estimating on their own plant at lesser rates.

Contractor's Own Plant

This section deals with the contractor's own plant, his purchase of it, how he writes off his capital outlay, its years of life, working hours per annum, and its working cost per hour.

Most firms have their own scale of charges for the hire per hour of their own plant. These rates include for capital cost, interest on outlay and depreciation, as well as repairs and renewal costs, but are exclusive of the operator's wages, fuel, oil, and grease. The operator's wages are covered on the contract, as they appear on the wage sheets, while fuel, oil, and grease are covered under consumable stores.

These rates of hire per hour are all tabulated for the different types of plant and the estimator bases his tender on them. When the plant goes on to a contract it is then also charged to that contract at those same rates. At the end of the plant's assessed life, it is usually written off, though in actual fact it may still be of some value either by being capable of doing further work or as an article which may be sold.

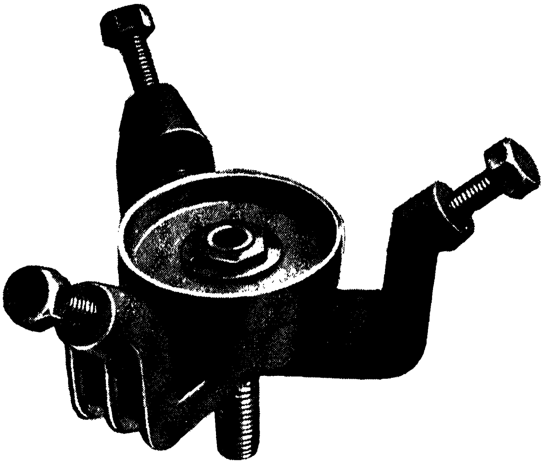

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FIG. 34.—TESTING PLUG

The Working Cost per hour

The factors on which the working cost per hour depend are:

(1) The initial cost of the machine.
(2) The interest on the outlay.
(3) The depreciation (number of years of life of the plant).
(4) The cost of repairs and renewals (maintenance).
(5) The number of hours the plant works per annum.
(6) The running cost—fuel, oil, grease, etc. (consumable stores).
(7) The operator's wages.
(8) The insurance of the plant.
(9) Licence cost, if any.

Note.—In connection with (2) some builders and contractors allow interest on the outlay expended in the purchase of plant, this usually being done by adding a fixed percentage per annum to the capital cost of the plant for each year of its life as shown in the example.

Another method is to allow no interest on the outlay, the purchase of the plant being looked upon as an investment, since the plant, in carrying out work, will presumably make a profit. The interest on outlay is considered as being recovered in this profit. This latter method is a businesslike and very simple way of dealing with the matter since no interest calculations are required. It has much to recommend it and might be referred to as the "Straight Line" method.

The Working Hours of the Plant per annum

Plant does not work every hour of the week all the year round. Such items as repairs, periods of pause between contracts, weather conditions, etc., enter into this. For purposes of calculating the working cost per hour of plant, therefore, some figure representing how many hours it will work per annum must be assessed. A lorry, for instance, may work to all intents and purposes all the year round, but a tractor and scraper may only work on eight months of the year. As the life of plant depends on how many hours it works, a fair average figure is usually arrived at on which to base one's calculations. This is reasonable in that plant standing idle does not depreciate at anything like the rate it does when working. A fair average number of working hours per annum is:

An allowance of 34 weeks of 48 hours per week

= 1,632 hours per annum, and the data shown is based on this figure.

The Cost of Repairs and Renewals per annum

All plant has to have money expended upon it in order to keep it in first-class working condition and for a contract to be successfully carried out. In regard to both speed of construction and profit, sound plant is essential. A plant engineer with assistants is usually employed where a lot of plant has to be looked after, and the operators of the plant generally carry out themselves all minor running repairs. The costs of maintenance are very variable. A good, careful driver will keep his plant well, anticipate trouble and rectify it before big damage results, while the slipshod driver will, if not watched, drive the machine until perhaps serious and costly breakdown may result. The cost of repairs again depends on how many hours the plant works, so must be treated as a cost per working hour. Most firms keep careful records of repairs and renewals costs for their various plants and arrive at repair and renewal costs per working hour, and allow accordingly when computing their plant hire rates.

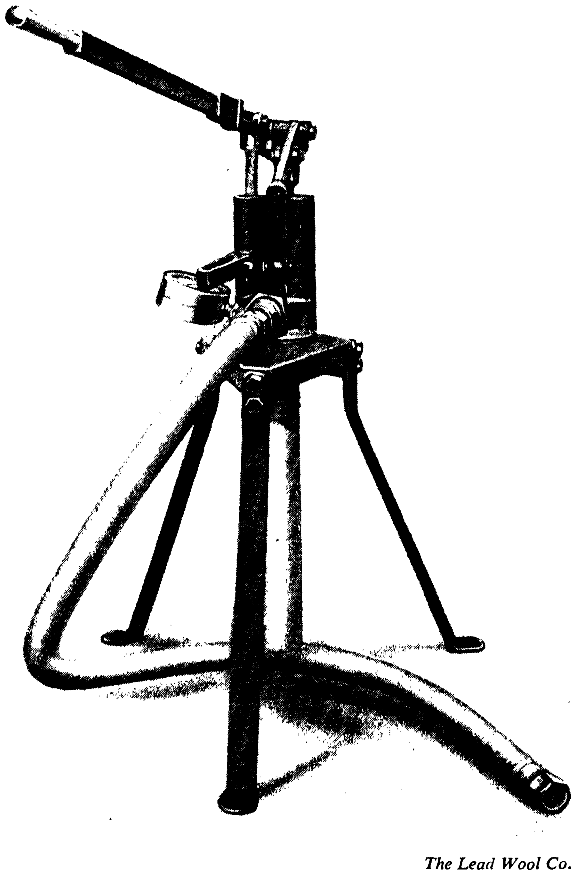

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FIG. 35.—TWIN-BARREL HYDRAULIC TEST PUMP

The cost per working hour to allow for maintenance and repairs works out at from 20% to 40% of the plant hire rate per hour, as worked out to cover the initial cost and depreciation of the plant. The method of making this addition can be seen in the example. For guidance a table is shown giving these percentage additions for various types of plant, and also the fuel and oil used by various types of plant. As mentioned before, it is difficult to give hard and fast figures for this repairs and renewals cost, but the percentage additions shown are fair average figures.

Example.—Showing the working cost per hour to allow for plant, allowing 1,632 working hours per annum to cover the cost of the plant, interest on outlay, and depreciation, and the additional percentage to cover repairs and renewals.

Money has to be spent to purchase the new plant and also interest on outlay, and eventually the plant depreciates to such an extent that it is worn out and is of no further use. Its years of life must therefore be assessed so that this depreciation may be allowed for and also its average working hours per annum. Below is shown an example of how this is done.

Example:

A new ⅜ cu. yd. excavator is bought costing £1,500, and it is assessed that it will work for five years, at the end of which time it will be worn out. Working hours per annum, 1,632. Calculate the plant charge per hour to cover this outlay, interest and depreciation.

Initial cost of machine		£1,500	
Add 5% interest on outlay for 5 years		£375	
		£1,875	
Allowing a 5 year life cost per annum	=	$\frac{£1,875}{5}$	= £375
Allowing working hours per annum, 1,632.			
Cost per working hour	=	$\frac{£375}{1,632}$	
	=	4/6	
Add 40% for repairs and renewals per working hour (see table)	=	1/9	
Cost per working hour	=	6/3	

To get the total working cost per hour to the above must be added: the operator's wages, the fuel and oil and insurance, thus:

Hire rate per hour covering initial cost, interest, and depreciation	4/6	per hour
Repairs and renewals, 40% of above	1/9	,,
Operator's wages, say	2/6	,,
Fuel. Vaporizing oil (see table on page 236), 1·30 galls. at 1/3	1/5	,,
Lubricating oil ,, ,, ,, ,, 0·05 ,, ,, 8/-	-/4	,,
Insurances, say	-/3	,,
Total working cost per hour	10/9	

Note.—Insurances per working hour = $\frac{\text{Annual Cost of Insurance}}{\text{1,632 Working Hours per annum}}$.

Tables

Tables are shown for the following, which may be used to build up plant working costs per hour:

1. The average number of years of life of the most generally used plant, assuming that it is well serviced and kept in good repair based on annual working hours of 1,632.
2. The fuel and oil required per working hour by various types of machines.
3. The percentage addition to add for repairs and renewals to the plant hire cost per hour as worked out to cover the initial cost of the plant and interest on outlay.

TABLE SHOWING THE NUMBER OF YEARS OF LIFE OF THE MOST COMMONLY USED PLANT BASED ON PLANT WORKING 1,632 HOURS PER ANNUM

Type of plant	*No. of years of life of plant*	*Type of plant*	*No. of years of life of plant*
Concrete mixers	5	Lorries, petrol	3
Compressors	5	,, steam	10
Cranes, petrol or Diesel	5	Locos, petrol or Diesel	6
,, steam	10	,, steam	10
Dumpers	3	Pumps, petrol	5
Excavators, bucket type trenchers	5	,, steam	10
,, mechanical navvies, etc.	5	Private cars	3
,, tractors and scrapers	5	Rollers, Diesel	8
Hoists, petrol or Diesel	5	,, petrol	5
Hi-lift shovels	3	,, steam	12
Lorries, Diesel	5		

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FIG. 36.—ANDUN BLACK TOP PAVER

TABLE SHOWING FUEL AND OIL REQUIRED BY VARIOUS PLANTS PER WORKING HOUR

Type of plant	*Fuel required per hour*				*Lubricating oil galls./hr.*
	Coal cwts./hr.	*Diesel oil galls./hr.*	*Vaporising oil galls./hr.*	*Petrol galls./hr.*	
Compressors, 2-tool petrol	—	—	—	1·30	0·018
„ 2-tool Diesel	—	0·80	—	—	0·018
„ 3-tool petrol	—	—	—	1·50	0·025
„ 3-tool Diesel	—	1·00	—	—	0·025
Concrete mixers, 7/5	—	—	—	0·50	0·012
„ „ 10/7	—	—	—	0·60	0·015
„ „ 14/10	—	—	—	0·70	0·020
„ „ 21/4	—	—	—	1·00	0·022
Crane, 8 cwt. petrol	—	—	—	0·80	0·020
„ 12/15 „	—	—	—	1·00	0·022
„ 20 „	—	—	—	1·40	0·030
„ steam, 3 ton	1·00	—	—	—	0·020
Dumper, 2 cu. yd.	—	—	—	1·00	0·020
„ 3 cu. yd.	—	—	—	1·30	0·024
Excavator, bucket trencher 16/60	—	—	—	1·70	0·040
„ „ „ 12/18	—	—	—	1·30	0·030
Mechanical excavator, ¼ cu. yd. vaporising or Diesel	—	0·70	1·20	—	0·020
„ „ ⅜ cu. yd. ditto	—	0·80	1·30	—	0·022
„ „ ½ cu. yd. ditto	—	1·00	1·40	—	0·024
High-lift shovel, ½ cu. yd.	—	—	—	0·90	0·022
Hoist, petrol	—	—	—	0·70	0·018
Locos, 20 h.p. petrol	—	—	—	1·20	0·025
„ 20 h.p. Diesel	—	0·80	—	—	0·025
Lorries, petrol, 2 ton	—	—	—	0·90	0·020
„ „ 3 ton	—	—	—	1·00	0·022
„ „ 4 ton	—	—	—	1·10	0·024
„ „ 5 ton	—	—	—	1·20	0·026
„ „ 6 ton	—	—	—	1·30	0·028
Pumps, 3 in. petrol	—	—	—	0·50	0·020
„ 4 in. „	—	—	—	0·60	0·030
„ 5 in. „	—	—	—	0·80	0·040
„ 6 in. „	—	—	—	1·00	0·050
Roller, 2 ton petrol	—	—	—	0·70	0·020
„ 4 ton „	—	—	—	0·90	0·025
„ 6–8 ton Diesel	—	1·00	—	—	0·030
„ 6–8 ton steam	0·80	—	—	—	0·040
„ 8–10 ton „	1·00	—	—	—	0·044
D4 tractor with scraper	—	1·80	—	—	0·040
D6 „ „ „	—	2·50	—	—	0·060
D7 „ „ „	—	4·00	—	—	0·090
D8 „ „ „	—	5·00	—	—	0·150

Plant Repairs and Renewal Costs per Working Hour of the Plant

Table showing the percentage addition to add to the plant hire cost per hour as worked out to cover initial cost of the plant and interest on outlay to allow for the repairs and renewals cost per working hours of the plant is given overleaf.

The table is based on plant working 1,632 hours per annum.

PERCENTAGE ADDITION TO PLANT HIRE COST PER HOUR

Type of plant	*Repairs and renewals. Cost per working hour. Percentage addition to add to the initial outlay and interest on outlay cost per working hour*
Compressors	25%
Concrete mixers	30%
Cranes, petrol	30%
„ steam	20%
Dumpers	37½%
Excavators, bucket trencher type	37½%
„ navvies, skimmers, etc.	40%
Hi-lift shovels, petrol	33⅓%
Hoists, petrol	30%
Locos, petrol or Diesel	30%
„ steam	20%
Lorries, petrol or Diesel	30%
„ steam	20%
Pumps, petrol	25%
„ steam	20%
Rollers, Diesel	25%
„ petrol	25%
„ steam	20%
Tractors with scrapers, etc.	40%

Steel Scaffolding

Work can be carried out by bricklayers, plasterers, etc., from ground or floor level only to a certain height, after which, scaffolding has to be used in order that they may reach the work.

It should be noted that plasterers, electricians, painters, decorators, etc. may all use the same scaffolding to carry out their work so that the cost of erecting and dismantling the scaffolding should really be apportioned to each. From an estimating point of view however, it is usual to provide for the scaffolding costs under one trade, and this is usually done by allowing for it under "Bricklayer" for the brickwork scaffolding and "Plasterer" for the other.

Under the various trade sections shown throughout this book the labour cost of work at height is allowed for by the use of multipliers in conjunction with the main estimating tables, and this is a very simple way of dealing with it.

The estimator should note that the cost of scaffolding if required must be allowed for in addition. In this connection it is pointed out that in works of repair to brickwork, plaster, etc. scaffolding may be required in which case its cost must be taken into account.

Steel Scaffolding for Bricklayers

Note.—(1) Putlog scaffolding, 3 ft. 9 in. working platforms at 4 ft. 4 in. lifts and with standards at 7 ft. 6 in. centres.

(2) Independent scaffolding 3 ft. 9 in. working platforms at 4 ft. 4 in. lifts and standards at 7 ft. 6 in. centres.

In each case 4½ in. plumbing space is left and the hours shown allow for all ties, braces, access ladders and scaffold boards and also for the fixing of handrails and toe boards to the third lift and over.

Description	*Unit*	*Labour hours per unit*		
		Erect Scaffolding	*Dismantle Scaffolding*	*Erect and Dismantle Scaffolding*
Putlog scaffolding ..	sq. yd.	0·44	0·18	0·62
Independent scaffolding ..	,,	0·54	0·22	0·76

For timber scaffolding use a multiplier of 1·25 with the labour hours shown.

TABLE OF MULTIPLIERS FOR USE WITH THE ABOVE TABLE FOR DIFFERENT HEIGHTS OF WORKS

Height of Work above Ground in Feet	*Labour Hour Multipliers*
0–40	1·00
41–60	1·10
61–80	1·25
81–100	1·45

STEEL SCAFFOLDING FOR PLASTERER

Note.—(1) Putlog scaffolding with 4 ft. 6 in. working platforms at 7 ft. 6 in. lifts and standards at 7 ft. 6 in. centres.

(2) Independent scaffolding with 4 ft. 6 in. working platforms at 7 ft. 6 in. lifts and standards at 7 ft. 6 in. centres.

(3) Birdcage access scaffolding with uprights at a maximum of 10 ft. centres and 6 ft. 6 in. lifts. Boards all round to each lift.

In each case the hours shown allow for all ties, bracing, access ladders and scaffold boards, also for the fixing of hand rails and toe boards to the second lift and over.

Description	*Unit*	*Labour Hours per Unit*		
		Erect Scaffolding	*Dismantle Scaffolding*	*Erect and Dismantle Scaffolding*
Putlog scaffolding	sq. yd.	0·30	0·12	0·42
Independent scaffolding	,,	0·35	0·14	0·49
Birdcage access scaffolding	cu. yd.	0·05	0·02	0·07

For timber scaffolding use a multiplier of 1·25 with the labour hours shown.

TABLE OF MULTIPLIERS FOR USE WITH THE ABOVE TABLE FOR DIFFERENT HEIGHTS OF WORKS

Height of Work above ground	*Labour Hour Multipliers*
0–40	1·00
41–60	1·15
61–80	1·35
81–100	1·60

SECTION TWENTY-ONE

★

PLASTERER

Plastering work consists of interior plastering, using lime mortars; exterior work in cement mortars, sometimes called rendering, and work to floors.

In allowing for the quantity of material required per sq. yd. allowance must be made for the extra thickness of material required over and above the finished thickness. This is necessary to allow for:

(1) The consolidation due to compressing the mortar when trowelling it on.

(2) Any slight loss of material due to droppings, etc.

(3) The irregularities of the surface being treated.

A table showing the sq. yds. covered by 1 cu. yd. of mortar in which allowance has been made for the above three factors has been included. This table should be used when calculating the material cost per sq. yd.

The work may be carried out in one, two, or three coats, as follows:

One-coat Work.—This would normally be laid about ½ in. thick.

Two-coat Work.—The first coat would normally be ½ in. to ¾ in. thick, with a second or finishing coat of ¼ in. thickness.

Three-coat Work.—The first coat normally would be ½ in. thick, followed by a second coat ⅜ in. thick, and the third or finishing coat about ¼ in. thick.

Three-coat work is not common. One- and two-coat work is general.

SQUARE YARDS COVERED BY 1 CUBIC YARD OF MORTAR ON BRICK WALLS

Finished thickness of work in inches	*Sq. yards covered by 1 cu. yd. of mortar*
¼	75
⅜	60
½	50
⅝	41
¾	33
⅞	29
1	26

Note.—The hours shown do *not* include for mixing the mortars. For mortar tables see page 208.

PLASTERING TO WALLS IN LIME MORTAR PER SQUARE YARD

Description	*Unit*	*Plasterer hours*	*Labourer hours*
Plaster and set in lime mortar and hair	sq. yd.	0·30	0·30
Plaster and set with fine material	„	0·40	0·40
Plaster, float, and set with fine material	„	0·50	0·50
Sirapite only in 2-coat work	„	0·50	0·50
Keene's cement on and including cement and sand backing . .	„	0·75	0·75

PLASTERING TO CEILINGS IN LIME MORTAR PER SQUARE YARD

Description	*Unit*	*Plasterer hours*	*Labourer hours*
Fix lathing	sq. yd.	0·25	0·25
Render and set with fine material .		0·45	0·45
Sirapite on 4 to 1 cement and sand		0·50	0·50

SUNDRY WORKS IN CONNECTION WITH PLASTERING IN LIME MORTAR

Description	*Unit*	*Plasterer hours*	*Labourer hours*
Form cornices or coves per inch girth	lin. ft.	0·07	0·07
stops	each	0·04	0·04
mitres	,,	0·07	0·07
returned mitre ends	,,	0·10	0·10

RENDERING IN CEMENT MORTAR TO FLOORS PER SQUARE YARD

Description	*Unit*	*Plasterer or bricklayer hours*	*Labourer hours*
Render ½ in. thick	sq. yd.	0·25	0·25
¾ in. ,, ...	,,	0·30	0·30
1 in. ,, ...	,,	0·36	0·36

RENDERING IN CEMENT MORTAR TO WALLS PER SQUARE YARD

Description	*Unit*	*Plasterer or bricklayer hours*	*Labourer hours*
Render ½ in. thick to brick walls in 1 coat	sq. yd.	0·40	0·40
in. ,, ,, ,, 1 ,, ...	,,	0·45	0·45
1 in. ,, ,, ,, 2 coats	,,	0·55	0·55

SUNDRY WORKS IN CONNECTION WITH CEMENT RENDERING

Description	*Unit*	*Bricklayer hours*	*Labourer hours*
Rake out joints for key required to brick walls	sq. yd.	0·10	0·10
Hack existing cement rendering	,,	0·30	0·30
Form arris	lin. ft.	0·06	0·06
,, rendered angles	,,	0·10	0·10
Cement wash, floors	sq. yd.	0·15	0·15
,, ,, walls and ceilings		0·20	0·20

For GRANOLITHIC PAVING, see page 257.

For table showing cement and sand and lime and sand per cubic yard of mortar, see page 91.

SECTION TWENTY-TWO

★

PLATELAYER

RAILS 75 POUNDS PER LINEAL YARD CENTRE LINE OF DOUBLE RAILS

Item		*Platelayer hours*	*Labourer hours*
Unload and string out rails per yard. Double rail.		—	0·80
Off-load and lay sleepers	each	—	0·50
Lay 75 lb. rails, straight double rail	per lin. yard	0·50	4·00
„ „ „ curved double rail	„ „ „	0·64	5·12
„ bottoming ballast, per cu. yd.		—	1·20
Pack up rails and sleepers, lin. yd. a head, double rail		0·20	1·60

LAY DECAUVILLE TRACK, 12/14 POUNDS PER LINEAL YARD CENTRE LINE OF DOUBLE RAILS

Item		*Labourer hours*	
		Steel sleepered rails	*Wooden sleepers, spiked*
Off-load from lorry and string out	Per lin. yard	0·06	0·04
Lay rails/lin. yard double rail		0·10	0·15
Take up rails and load in lorry. Double rail	Per lin. yard	0·12	0·16
Off-load and lay wooden sleepers	each	—	0·05

SECTION TWENTY-THREE

★

PLUMBER

Under this section is shown the "plumber and mate" hours for the type of plumbing work generally carried out. This consists of such work as the laying and fixing of lead pipes, wrought iron piping, gutters, etc. The laying of water mains, often embodied in this section, has been included under the section devoted to "Pipelayer", to which reference should be made for details of this class of work.

Specialist Work

No attempt has been made to show data covering works which are outside normal building works, such as hot-water heating, radiators, etc., as this is specialist's work. Should much of this specialist work appear in a bill of quantities when tendering for a contract, the estimator should call for outside estimates for the work in question from two or three of the better-known firms who specialise in this class of work and use these as a basis for his estimate. A decision can then be made to carry out the work by sub-contract or otherwise. If the latter, a percentage addition can be added to the tender received from the specialised firm whom it is decided to put on the work. This ensures the covering of overheads and a profit. This percentage addition would, in all probability, range from 5% to 10%.

FIX SHEET LEAD PER CWT.

Description	*Unit*	*Plumber hours*	*Labourer hours*
To gutters and flashings	cwt.	7·80	7·80
sinks, cisterns, etc.	,,	6·50	6·50
in flats and roofwork	,,	5·00	5·00

FIX LEAD PIPES INCLUDING ALL BENDS TO BRICK WALLS, PER LINEAL YARD

Note.—(1) For lead pipes fixed to timber use a multiplier of 0·75 with the plumber and labourer hours shown.

(2) For pipes in short lengths use a labour multiplier of 2·00 with the plumber and labour hours shown.

Diameter inches	*Unit*	*Plumber hours*	*Labourer hours*
½	lin. yd.	0·30	0·30
¾	,,	0·36	0·36
1	,,	0·42	0·42
1¼	,,	0·50	0·50
1½	,,	0·60	0·60
2	,,	0·75	0·75

LAY LEAD PIPES IN TRENCHES, PER LINEAL YARD

Note.—(1) For pipes up to 1 in. diameter allow 1 soldered joint and 2 bends per 60 ft. length of pipe.

(2) For pipes over 1 in. diameter allow 1 soldered joint and 1 bend per 36 ft. length of pipe.

(3) For pipes in short lengths use a labour multiplier of 2·00 with the plumber and labourer hours shown.

Diameter	*Plumber*	*Labourer*
½	0·10	0·10
¾	0·12	0·12
1	0·14	0·14
1¼	0·16	0·16
1½	0·18	0·18
2	0·24	0·24

FIXING STEEL WATER TUBING INCLUDING ALL BENDS TO WALLS PER LINEAL YARD. SCREWED JOINTS

Diameter inches	*Unit*	*Plumber hours*	*Labourer hours*
½	lin. yard.	0·33	0·33
¾	,,	0·40	0·40
1	,,	0·46	0·46
1¼	,,	0·55	0·55
1½	,,	0·66	0·66
2	,,	0·82	0·82

LAY STEEL WATER TUBING IN TRENCHES PER LINEAL YARD SCREWED JOINTS

Diameter inches	*Plumber hours*	*Labourer hours*
½	0·08	0·08
¾	0·10	0·10
1	0·12	0·12
1¼	0·14	0·14
1½	0·16	0·16
2	0·18	0·18

MAKE SOLDERED JOINTS

Diameter inches	*Plumber hours*	*Labourer hours*
½	0·60	0·60
¾	0·70	0·70
1	0·80	0·80
1¼	0·90	0·90
1½	1·00	1·00
2	1·20	1·20

FIX CAST IRON VENTILATING PIPES TO WALLS, PER LINEAL YARD

Diameter inches	*Unit*	*Plumber hours*	*Labourer hours*
3	lin. yard	0·40	0·40
3½	,,	0·50	0·50
4	,,	0·60	0·60
5	,,	0·70	0·70
6	,,	0·80	0·80

WEIGHT AND THICKNESS OF SHEET LEAD, POUNDS PER SQUARE FOOT

Pounds per sq. foot	*Thickness inches*
1	0·02
2	0·03
3	0·05
4	0·07
5	0·09
6	0·10
7	0·12
8	0·14
9	0·15
10	0·17
11	0·19
12	0·20

PLUMBER: SUNDRY WORKS

Description	*Unit*	*Plumber Hours*	*Labourer Hours*
Bossed Angles to Aprons	each	0·80	0·80
„ „ „ Flats	„	1·60	1·60
„ „ „ Gutters	„	2·20	2·20
Fix Aprons	cwt.	7·00	7·00
„ Flats to Roofs	„	6·60	6·60
„ Hips and Ridges	„	9·00	9·00
„ Weathering to Chimneys, etc.	„	7·50	7·50
„ Baths	each	4·00	4·00
„ Cisterns—Cold Water	„	2·50	2·50
„ „ Hot Water	„	4·00	4·00
„ „ W.C. to Boards	„	0·80	0·80
„ Flushing Pipes	„	1·00	1·00
„ Kitchen Sinks	„	3·00	3·00
„ Wash Hand Basins	„	3·00	3·00
„ W.C. Pans	„	0·75	0·75
Soldered or Wiped Seams	lin. ft.	0·60	0·60
„ „ „ Angles	„	0·90	0·90

WEIGHT OF LEAD PIPES PER LINEAL FOOT

Diameter inches	*Weight in lb. per lin. ft.*		
	Light	*Medium*	*Heavy*
½	1·10	1·40	2·00
¾	1·50	2·00	3·00
1	2·30	3·00	4·00
1¼	3·00	4·00	5·40
1½	4·00	5·40	6·00
2	5·00	6·80	8·00

SECTION TWENTY-FOUR

★

ROADMAKER

The making of roads usually forms a large part of a civil engineer's or surveyor's work, and under this section the main types of roads and paths generally met with are shown. These are:

1. Waterbound macadam roads.
2. Tarmacadam roads.
3. Concrete roads.
4. Footpath work and pavings.

Regarding tarmacadam roads, the costs of tarmacadam production itself are not shown, as this is, in most cases, purchased direct from the manufacturers, of whom there are many in all parts of the country.

In constructing roads, various factors have to be noted as these affect the cost of the work. These are:

1. *The nature of the subsoil.* A hard good-bearing ground holds up the material being rolled, whilst a soft spongy formation tends to absorb more material before consolidation is secured.
2. *The time of year.* Wet weather bogs the formations, frost affects concreting, necessitating covering carefully the finished work with straw, mats, etc.
3. *Bulkage of materials.* This has to be allowed for as they are delivered and paid for in the loose and compress considerably under the weight of the roller when being consolidated. This bulkage figure tends to vary depending on
    (1) The nature of the subsoil.
    (2) The class of material used.
    (3) The weight of roller used.

In the tables for laying hardcore, clinker, ballast, etc., the percentage allowance for bulkage of material has been arrived at from costs and quantities averaged over all periods of the year, and strikes a fair average. The estimator must use his initiative if the subsoil is really abnormal, such as a peat bog or ground of a very soft spongy nature, and increase the percentage bulkage accordingly. For all normal subsoils, such as clay, sand, ballast, loam, etc., the percentage bulkages should be used as shown in the tables.

Emphasis is placed on the necessity of seeing to it that the plant, whether it be heavy mechanical rollers or concrete mixers, is worked to capacity, and that raw materials are fed to it in sufficient amount to ensure that this is so, in order that the costs may be low. In the various tables, it will be noted that hour constants are shown for various deliveries per hour. The estimator should tender on a guaranteed delivery per hour and the engineer whose responsibility it is to run the work should ensure that this is adhered to, or, better still, surpassed if the machine is not working to capacity.

The proportions of labour to use with the plant for various deliveries of material can be seen under the "Plant and Labour to Use", Section Eight.

Clinker, Ashes, or Ballast Laid and Rolled per cu. yd.

In the laying and rolling of clinker or ballast, the quantity delivered to site per hour has a great bearing on the cost, as it is essential that the roller (a costly item) be worked to capacity, if low costs are to be achieved. In the case of ashes, clinker, or ballast, a 2 ton petrol roller will roll 10 cu. yds. of loose material, as delivered, per hour, for consolidated depths of 2 to 6 in., so every attempt should be made by the engineer on the job to get this delivery. It will be seen from the tables how the cost per cu. yd. increases, as delivery decreases below this amount, due to the roller hour constants rising. When tendering the estimator is advised to get from the suppliers not only the price per cu. yd. delivered to site, but also the average hourly delivery in cu. yds., and base his price accordingly.

Note.—(1) *Add* 33⅓% *bulkage to cost of ashes, or clinker to allow for consolidation.*

(2) *Add* 25% *bulkage to cost of ballast to allow for consolidation.*

(3) Rolling carried out by mechanical roller—2 ton or 4 ton petrol roller.

Cu. yds of material delivered per hr.	*Clinker, ashes, or ballast laid and rolled per cu. yd. Consolidated depth laid*									
	2 *ins.*		3 *ins.*		4 *ins.*		5 *ins.*		6 *ins.*	
	Lab. hours	*Roller hours*	*Lab. hours*	*Roller hours*	*Lab. hours*	*Roller hours*	*Lab. hours*	*Roller hours*	*Lab. hours*	*Roller hours*
4	0·80	0·25	0·66	0·25	0·60	0·35	0·55	0·25	0·50	0·25
5	0·80	0·20	0·66	0·20	0·60	0·20	0·55	0·20	0·50	0·20
6	0·80	0·17	0·66	0·17	0·60	0·17	0·55	0·17	0·50	0·17
7	0·80	0·15	0·66	0·15	0·60	0·15	0·55	0·15	0·50	0·15
8	0·80	0·13	0·66	0·13	0·60	0·13	0·55	0·13	0·50	0·13
9	0·80	0·12	0·66	0·12	0·60	0·12	0·55	0·12	0·50	0·12
10	0·80	0·10	0·66	0·10	0·60	0·10	0·55	0·10	0·50	0·10

1 cu. yd. clinker = 12·70 cwts.

Example:

If clinker costs 8/- per cu. yd., calculate tender rate per cu. yd. to show 20% gross, for clinker laid 3 ins. thick consolidated when labour rate is 2/- per hour and hire of 2 ton petrol roller is 6/- per hour, and material delivery is guaranteed at an average of 6 cu. yds. per hour.

Material cost	8/-	cu. yd.
Add 33⅓ % bulkage	2/8	„
Labourer hours from tables, 0·66 at 2/- .. .	1/4	„
2 ton petrol roller hours from tables, 0·17 at 6/-	1/-	„
∴ Cost	13/-	
Add 20%	2/8	
Tender, price .. .. .. =	15/8	cu. yd.

∴ 3 ins. = 1/4 per sq. yd.

Concreting Roads and Large Areas with Concrete Mixers of the Drum and Hopper Type, the Mixers being Mechanically Loaded or Loaded by Hand

In concreting large areas of mass-foundations or where a considerable output is required, it is common practice to use mixers of the drum and hopper type, these being mechanically loaded by Hi-lift shovels, small grabs, or draglines. The advantages of this are:

(1) The cost per cu. yd. of mixing the concrete is cheaper than by hand.

(2) The output is increased.

This plant set up can be used to advantage in concreting large areas such as roads, runways, factory floors, and so on.

Tables are shown for the output of concrete mixers of the 10/7, 14/10, and 21/14 class, fed either by hand or machines, as well as a table showing the plant and labour hours per cu. yd., for mixing and placing only.

Transporting the concrete is not included, for which see pages 105 to 107 and 120.

A table is also shown under Section Eight for the gang of men required to mix and place the concrete, for the various sizes of mixers, fed either by hand or by machines.

Concreting to Roads and Large Areas, Mixing and Placing only, with Mixers of the Drum and Hopper Type, Loaded by Hand and Mechanically per cu. yd.

Note.—(1) Transporting the concrete from the mixer to the site of the work is *not* included in this table. See pages 123 to 125 and 138.

(2) The plant and labour hours per cu. yd. shown allow for all tamping.

(3) The labour hours do not include for curing, bullnosing to edges, or screeding. See page 250.

10/7 CONCRETE MIXER

Plant and labour	*Unit*	*Method of loading, type of work, and plant and labour hours per cu. yd.*							
		By hand		*By Hi-lift shovel*		*By dragline*		*By grab*	
		Large areas, roads, or mass concrete	*Normal foundations, floors, etc.*	*Large areas, roads, or mass concrete*	*Normal foundations, floors, etc.*	*Large areas, roads, or mass concrete*	*Normal foundations, floors, etc.*	*Large areas, roads, or mass concrete*	*Normal foundations, floors, etc.*
Concrete mixer and driver . .	hrs/c.yd.	0·25	0·30	0·21	0·31	0·20	0·30	0·19	0·29
Hi-lift shovel and driver . .	,,	—	—	0·21	0·31	—	—	—	—
Dragline and driver . .	,,	—	—	—	—	0·20	0·30	—	—
Grab and driver	,,	—	—	—	—	—	—	0·19	0·29
Labourer . .	,,	2·00	2·40	1·66	1·90	1·60	1·80	1·54	1·72

For Reinforcement and Sundry Works to Concrete Roads, see page 250.

14/10 CONCRETE MIXER

Plant and labour	*Unit*	*Method of loading, type of work, and plant and labour hours per cu. yd.*							
		By hand		*By Hi-lift shovel*		*By dragline*		*By grab*	
		Large areas, roads, or mass concrete	*Normal foundations, floors, etc.*	*Large areas, roads, or mass concrete*	*Normal foundations, floors, etc.*	*Large areas, roads, or mass concrete*	*Normal foundations, floors, etc.*	*Large areas, roads, or mass concrete*	*Normal foundations, floors, etc.*
Concrete mixer and driver . .	hrs/c.yd.	0·20	0·23	0·17	0·22	0·16	0·21	0·15	0·20
Hi-lift shovel and driver . .	,,	—	—	0·17	0·22	—	—	—	—
Dragline and driver . .	,,	—	—	—	—	0·16	0·21	—	—
Grab and driver	,,	—	—	—	—	—	—	0·15	0·20
Labourer . .	,,	1·80	2·07	1·50	1·56	1·44	1·60	1·39	1·50

For Reinforcement and Sundry Works to Concrete Roads, see page 250.

21/14 CONCRETE MIXER

Plant and labour	*Unit*	*Method of loading, type of work, and plant and labour hours per cu. yd.*							
		By hand		*By Hi-lift shovel*		*By dragline*		*By grab*	
		Large areas, roads, or mass concrete	*Normal foundations, floors, etc.*	*Large areas, roads, or mass concrete*	*Normal foundations, floors, etc.*	*Large areas, roads, or mass concrete*	*Normal foundations, floors, etc.*	*Large areas, roads, or mass concrete*	*Normal foundations, floors, etc.*
Concrete mixer and driver . .	hrs/c.yd.	0·14	0·18	0·12	0·15	0·12	0·14	0·11	0·13
Hi-lift shovel and driver . .	,,	—	—	0·12	0·15	—	—	—	—
Dragline and driver . .	,,	—	—	—	—	0·12	0·14	—	—
Grab and driver	,,	—	—	—	—	—	—	0·11	0·13
Labourer . .	,,	1·54	1·98	1·20	1·15	1·16	1·11	1·11	1·07

For Reinforcement and Sundry Works to Concrete Roads, see page 250.

Concreting to Roads and Large Areas, Mixing and Placing only, using Central Batching Plant or Continuous Type Mixers

Note.—(1) The table on page 249 shows Mix and Place only, including Tamping. For Haulage, see pages 123 to 125 and 138.
For Reinforcement and Sundry Works to Concrete Roads, see page 250.

(2) Mechanical grabs or draglines should be used to suit the mixer in order to feed it at correct rate, as shown on page 249.

(3) The labour hours do not include for curing, bullnosing to edges, or screeding. See page 250.

CONCRETING TO LARGE AREAS, MIXING AND PLACING ONLY, USING CENTRAL BATCHING PLANT OR CONTINUOUS MIXERS

Cu. yds. of concrete Output of mixers per hour	*Mixer hours per cu. yd.*	*Mechanical grab or dragline hours per cu. yd.*	*Labour hours per cu. yd. Mix and place only*
10	0·10	0·10	1·20
15	0·066	0·066	1·10
20	0·05	0·05	1·00
25	0·04	0·04	0·90
30	0·033	0·033	0·80

MULTIPLIERS FOR USE WITH THE ABOVE TABLE IN CARRYING OUT VARIOUS CLASSES OF WORK

Nature of work carried out	*Multiplier*
Roads, runways, and large areas . .	1·00
Mass foundations	1·10
,, walls	1·30

SIZE OF MECHANICAL GRAB OR DRAGLINE TO USE TO FEED THE MIXERS

Mixer output cu. yds.	*Size of grab or dragline cu. yds.*
10	¼
15	⅜
20	⅜
25	½
30	½

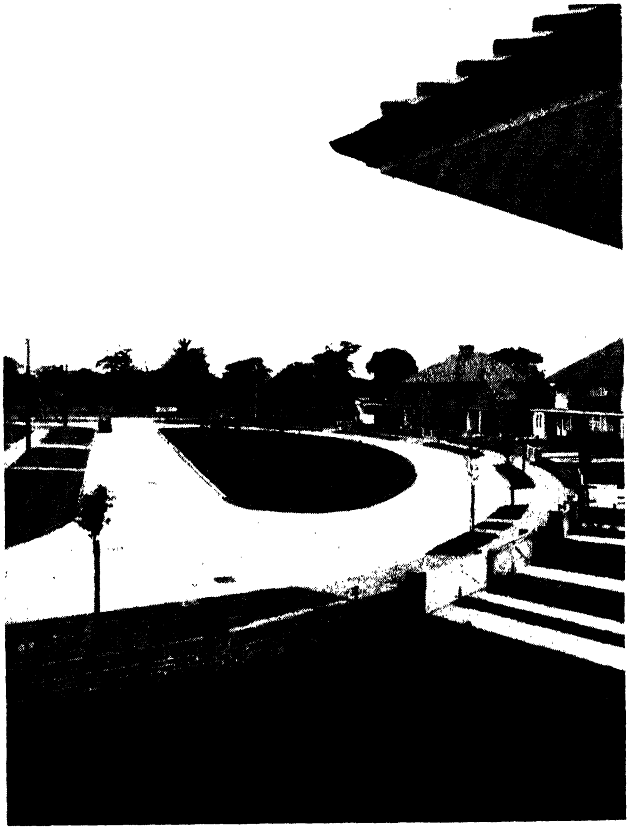


FIG. 37.—THE ILLUSTRATION ON THE RIGHT SHOWS HAMPTON COURT WAY, THAMES DITTON. THE ROAD IS CONSTRUCTED OF 6 IN. CONCRETE REINFORCED WITH A SINGLE LAYER OF B.R.C. REINFORCEMENT.

British Reinforced Concrete Engineering Ltd. Co.

SUNDRY WORKS TO CONCRETE ROADS

Description	*Unit*	*Labourer hours*
Curing with hessian	sq. yd.	0·08
„ „ sand	„	0·20
„ „ waterproof paper	„	0·08
Expansion joint—bitumen or felt, fixed	sq. ft.	0·15
„ „ run in elastite filler	lin. ft.	0·10
Reinforcement sheets, laid weight 3 lb. per sq. yd.	sq. yd.	0·04
„ „ „ „ 4 lb. „ „	„	0·05
„ „ „ „ 5 lb. „ „	„	0·06
„ „ „ „ 6 lb. „ „	„	0·07
„ „ „ „ 7 lb. „ „	„	0·08
Round edges with bullnosed trowels	lin. ft.	0·04
Screed and trowel surfaces	sq. yd.	0·40
Screed boards—timber, straight, and afterwards remove	sq. ft.	0·25
„ „ „ to slow sweeps, and afterwards remove	„	0·40
„ „ „ „ quick „ „ „	„	0·60
„ „ steel forms, and afterwards remove	„	0·16
Silicate of soda applied, per dressing	sq. yd.	0·02
Studded roller finish	„	0·06
Tamp with steel-shod tampers	„	0·12
„ „ leather or canvas belt finish	„	0·33

FIG. 38.—THIS ILLUSTRATION SHOWS THE TORBAY ROAD, TORQUAY, DEVON. THE ROAD IS TWO COURSE WORK. 6 IN. BOTTOM COURSE WITH 2 IN. BUFF COLORCRETE TOP COURSE

British Reinforced Concrete Engineering Co. Ltd.

Hardcore Laid and Rolled per cu. yd.

In the laying and rolling of hardcore the quantity delivered to site per hour has a great bearing on the cost, as it is essential the roller (a costly item) be worked to capacity, if low costs are to be achieved. In the case of hardcore a heavy steam or Diesel roller will roll 12 to 14 cu. yds. of loose material as delivered to site per hour, for consolidated depths of 6 to 12 in., so every effort should be made by the engineer on the job to get this delivery. It will be seen from the tables how the cost per cu. yd. increases as delivery decreases below this amount due to the roller hour constants rising.

When tendering the estimator is advised to get from the supplier not only the price per cu. yd. delivered to site, but also the guaranteed hourly delivery and to base his price accordingly.

Note.—(1) *Add* 38% *bulkage to cost of brick hardcore to allow for consolidation.*
(2) *Add* 33⅓% *bulkage to cost of stone hardcore to allow for consolidation.*
(3) *If hardcore be hand-packed multiply the labour hour constants by* 2·50.
(4) Rolling carried out by mechanical roller—6–8 or 8–10 tons in weight.

Brick hardcore	1 cu. yd. = 1 ton.	
Stone ,,	1 cu. yd. = 1·20 tons.	

Cu. yds. of material delivered per hour	*Hardcore laid and rolled per cu. yd. Consolidated depth laid*											
	3 *ins.*		4 *ins.*		5 *ins.*		6 *ins.*		9 *ins.*		12 *ins.*	
	Lab. hours	*Roller hours*	*Lab. hours*	*Roller hours*	*Lab. hours*	*Roller hours*	*Lab. hours*	*Roller hours*	*Lab. hours*	*Roller hours*	*Lab. hours*	*Roller hours*
4	0·90	0·25	0·85	0·25	0·80	0·25	0·75	0·25	0·60	0·25	0·45	0·25
6	0·90	0·17	0·85	0·17	0·80	0·17	0·75	0·17	0·60	0·17	0·45	0·17
8	0·90	0·13	0·85	0·13	0·80	0·13	0·75	0·13	0·60	0·13	0·45	0·13
10	0·90	0·10	0·85	0·10	0·80	0·10	0·75	0·10	0·60	0·10	0·45	0·10
12	0·90	0·09	0·85	0·09	0·80	0·09	0·75	0·09	0·60	0·09	0·45	0·09
14	0·90	0·08	0·85	0·08	0·80	0·08	0·75	0·08	0·60	0·08	0·45	0·08

Example:

If brick hardcore costs 9/– cu. yd., calculate tender rate per cu. yd. to show 20% gross, for hardcore laid 6 ins. thick, when labour rate is 2/– per hour, and 6–8 ton roller is 8/6 per hour, materials delivery is guaranteed at 8 cu. yds. per hour.

Material cost	9/–	cu. yd.
Add 38% bulkage	3/7	,,
Labourer hours from tables, 0·75 at 2/– ..	1/6	,,
6–8 ton roller hours from tables, 0·13 at 8/6	1/1	,,
∴ Cost ..	15/2	
Add 20% ..	3/1	
Tender, price =	18/3	

∴ 6 ins. = 3/0½ sq. yd.

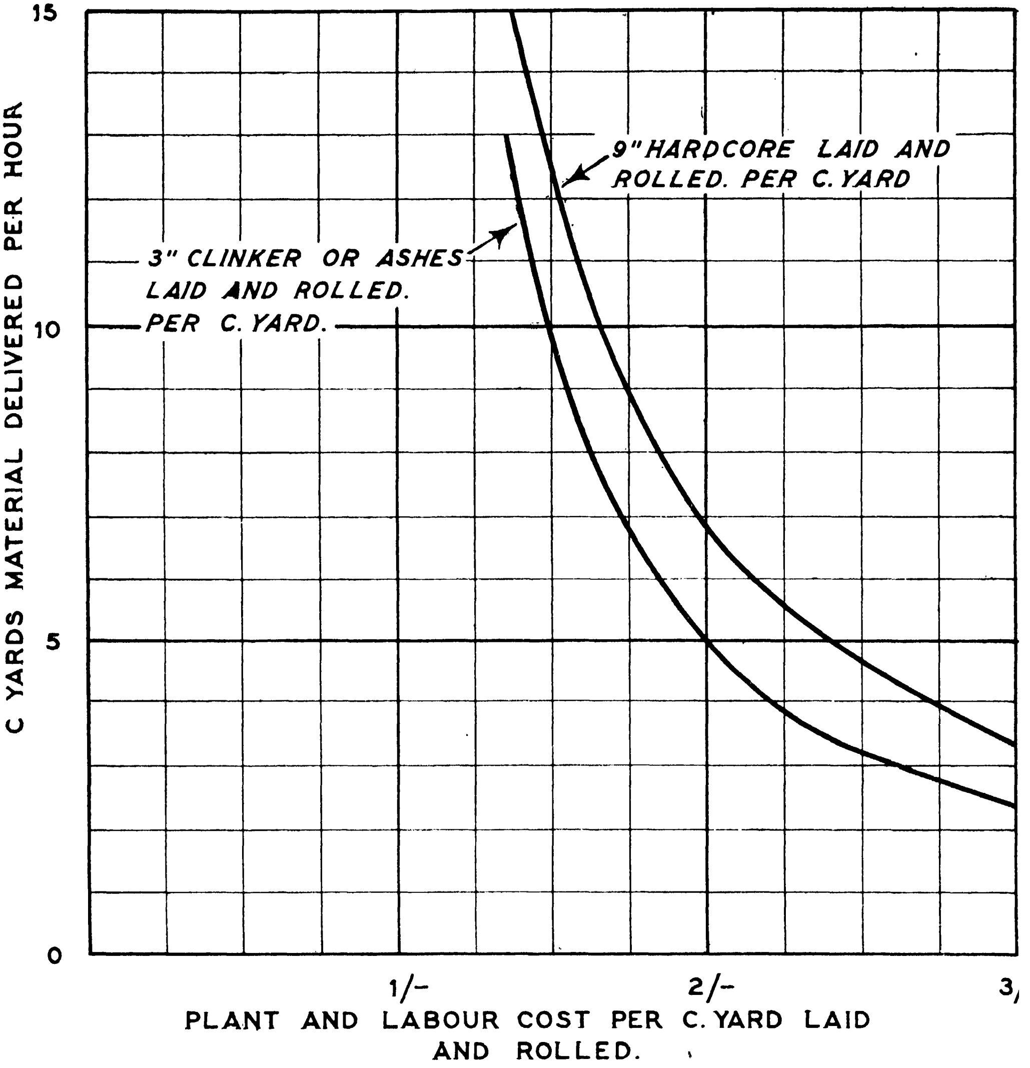


FIG. 39.—GRAPH ILLUSTRATING LAYING AND ROLLING COSTS

The above graph illustrates how the laying and rolling costs per cu. yd. of items such as clinker and hardcore mount in cost if the materials are not delivered to the roller up to its capacity to handle them.

A 2 ton petrol roller will roll approximately 6 cubic yards of clinker laid to a consolidated thickness of 3 in. per hour. A 6–8 ton roller will roll about 8 cubic yards of hardcore laid to a consolidated thickness of 9 in. per hour.

Lay and Roll Tarmacadam per sq. yd.

A heavy steam-roller will roll in one hour 7 tons of tarmacadam comfortably from 2 to 4 in. consolidated thickness. The estimator when pricing this item must have knowledge of the guaranteed hourly delivery as this greatly affects his price. It is essential if competitive low costs are to be achieved that the delivery be such, that the roller is working to capacity. The variation in cost as delivery becomes low can be clearly seen from the tables below, and it will be noted how much the roller cost rises if there is a decrease in delivery. It is, therefore, wise to get not only quotations for tarmac delivered to site, but to confirm also the guaranteed delivery and base the estimate accordingly.

TARMAC ROADS AND LARGE AREAS

Square yards covered by 1 ton of Tarmacadam

Sq. yds. per ton	*Consolidated thickness of tarmac laid sq. yds. per ton*				
	2 ins.	*2½ ins.*	*3 ins.*	*3½ ins.*	*4 ins.*
Slag	11·70	9·40	7·80	6·70	5·80
Limestone	12·00	9·70	8·00	6·90	6·00
Granite	11·00	8·80	7·30	6·30	5·50

TO ROADS AND LARGE AREAS

Rolled with Mechanical Roller, 6–8 tons in weight

Average tons delivered per hour	*Tarmacadam laid and rolled per sq. yd.*									
	2 ins.		*2½ ins.*		*3 ins.*		*3½ ins.*		*4 ins.*	
	Lab. hours	*Roller hours*	*Lab. hours*	*Roller hours*	*Lab. hours*	*Roller hours*	*Lab. hours*	*Roller hours*	*Lab. hours*	*Roller hours*
3	0·10	0·03	0·12	0·036	0·14	0·045	0·16	0·05	0·18	0·06
4	0·10	0·023	0·12	0·027	0·14	0·033	0·16	0·038	0·18	0·045
5	0·10	0·018	0·12	0·022	0·14	0·027	0·16	0·03	0·18	0·035
6	0·10	0·015	0·12	0·018	0·14	0·023	0·16	0·025	0·18	0·03
7	0·10	0·013	0·12	0·015	0·14	0·019	0·16	0·020	0·18	0·026

TO PATHS

Square yards covered by 1 ton of Tarmacadam. Rolled with 2 ton Petrol Roller

Sq. yds. per ton	*Consolidated thickness of tarmac laid per ton in sq. yds.*			
	1 in. per sq. yd.	*1½ ins. per sq. yd.*	*2 ins. per sq. yd.*	*2½ ins. per sq. yd.*
Slag	23·20	15·60	11·70	9·50
Limestone	24·00	16·00	12·00	9·80
Granite	21·90	14·60	11·00	8·90
Labourer hours	0·20	0·22	0·24	0·26
2 ton petrol roller hours	0·026	0·028	0·030	0·032

Note.—Tarmac topping is usually slightly dearer than the tarmac bottoming. An average price per ton should therefore be arrived at for the tarmacadam and used as in the example shown.

Thus, if ⅜ in. to ¼ in. tarmac is quoted at 32*s*. ton
and 1½ in. to ½ in. „ „ „ 30*s*. ton
and tarmac has to be 3 in. consolidated finished thickness with a bottom coat on 1½ in. to ½ in., material 2½ in. thick and a finishing coat of ⅜ in. to ¼ in. material ½ in. thick, the average price of tarmac per ton would be taken as

(½ in. ÷ 3 in.) (32/- − 30/-) + 30*s*.
= one-sixth of 2/- + 30*s*.
= 30/4 a ton.

Example:

If slag tarmacadam costs 30/4 per ton, calculate tender rate per sq. yd. laid in roads to show 15% gross for tarmac laid 2½ ins. thick consolidated when labour rate is 1/6 per hour and roller 7/6 per hour. The material delivery being guaranteed at 7 tons per hour.

Material cost		30/4 ton
Sq. yds. laid per ton from tables = 9·40		
∴ Material cost = $\frac{30/4}{9\cdot40}$	=	3/3 per sq. yd.
Labourer hours from tables, per sq. yd.	0·12 at 1/6	-/2 (2·16 pence)
6–8 ton roller hours from tables „	0·015 at 7/6	-/1½ (1·34 „)
∴ Cost per sq. yd.		3/6½
Add 15%		-/6½
∴ Tender		4/1 per sq. yd.

Tar and Cold Bituminous Emulsion Dressing to Roads, Parade Grounds, etc.

The above work is carried out, depending on the areas to be treated, by small portable plant or large pressure spraying plant.

For Small Areas—small portable boilers for hot tar or pressure-spraying plant on wheels pulled by hand, holding about one or more 40 gallon barrels, are used. They are not self-propelling and are usually fitted with wheels so that they can be drawn by hand or lorry. The rate of application is slow, but the plant is very useful on areas where an output of approximately 180 gallons per hour is sufficient and where the area to be covered would not merit the use of large plant.

For Large Areas—pressure-spraying plant mounted on a motor chassis is used. They move under their own power and hold anything up to 800 gallons at a time with a spraying rate of about 300 gallons per hour.

Plant and labour hour constants are shown for both types of plant and these constants include all sweeping down prior to applying the tar or emulsion, gritting or sanding, and also include sweeping up the loose grit after final rolling.

TABLE SHOWING SQUARE YARDS COVERED BY 1 CUBIC YARD OF VARIOUS SIZES OF GRIT

Size of grit	*Sq. yds. per cu. yd.*
Sand	220
⅛″	180
¼″	160
⅜″	140
½″	110
¾″	90

TAR DRESSING OR SURFACE DRESSING WITH COLD BITUMINOUS EMULSION OR HOT TAR TO ROADS USING SMALL PORTABLE BOILER OR PRESSURE TANK, INCLUDING SWEEPING DOWN AND GRITTING PER SQUARE YARD

Sq. yards per gall.	*Plant hours*	*Roller hours*	*Lorry hours*	*Labourer hours*
3	0·010	0·010	0·010	0·08
4	0·008	0·008	0·008	0·07
5	0·006	0·006	0·006	0·06
6	0·005	0·005	0·005	0·05

Note.—If hot tar, allow 0·004 cwts. coal per sq. yd.

TAR DRESSING OR SURFACE DRESSING WITH COLD BITUMINOUS EMULSION OR HOT TAR TO ROADS USING LARGE PRESSURE SPRAYING PLANT, INCLUDING SWEEPING DOWN AND GRITTING PER SQUARE YARD

Sq. yards per gall.	*Plant hours*	*Roller hours*	*Lorry hours*	*Labourer hours*
3	0·005	0·0030	0·0030	0·036
4	0·004	0·0020	0·0020	0·026
5	0·003	0·0016	0·0016	0·021
6	0·002	0·0014	0·0014	0·018

Note.—Tar supplied hot, the tank being lagged to ensure this while travelling to site.

Water-bound Roads, including all labourers slurrying in per cu. yd.

In laying and rolling the above the quantity delivered to site per hour has a great bearing on the cost, as it is essential to keep the roller (a costly item) worked to capacity, if low costs are to be achieved. In the case of water-bound roads a heavy steam or Diesel roller will roll 5 cu. yds. of loose material including slurrying-in per hour for consolidated depths of 2 to 4 in., so every effort should be made by the engineer on the job to regulate delivery to this amount. It will be seen from the tables how the cost per cu. yd. increases as delivery decreases below this amount, due to the roller hour constants rising.

When tendering the estimator is advised to get from the suppliers, not only the price per cu. yd. delivered to site, but also the guaranteed hourly delivery, and base his price accordingly.

Note.—(1) Add 25% bulkage to material cost to allow for consolidation.
(2) Rolling carried out by mechanical roller, 6–8 or 8–10 tons in weight.

Cu. yds. material delivered per hour	*Waterbound macadam laid and rolled per cu. yd. Consolidated depth laid*								
	2 *ins.*			3 *ins.*			4 *ins.*		
	Lab. hours	*Roller hours*	*Water-cart hours*	*Lab. hours*	*Roller hours*	*Water-cart hours*	*Lab. hours*	*Roller hours*	*Water-cart hours*
3	2·00	0·34	0·34	1·90	0·34	0·34	1·70	0·34	0·34
4	2·00	0·25	0·25	1·90	0·25	0·25	1·70	0·25	0·25
5	2·00	0·20	0·20	1·90	0·20	0·20	1·70	0·20	0·20

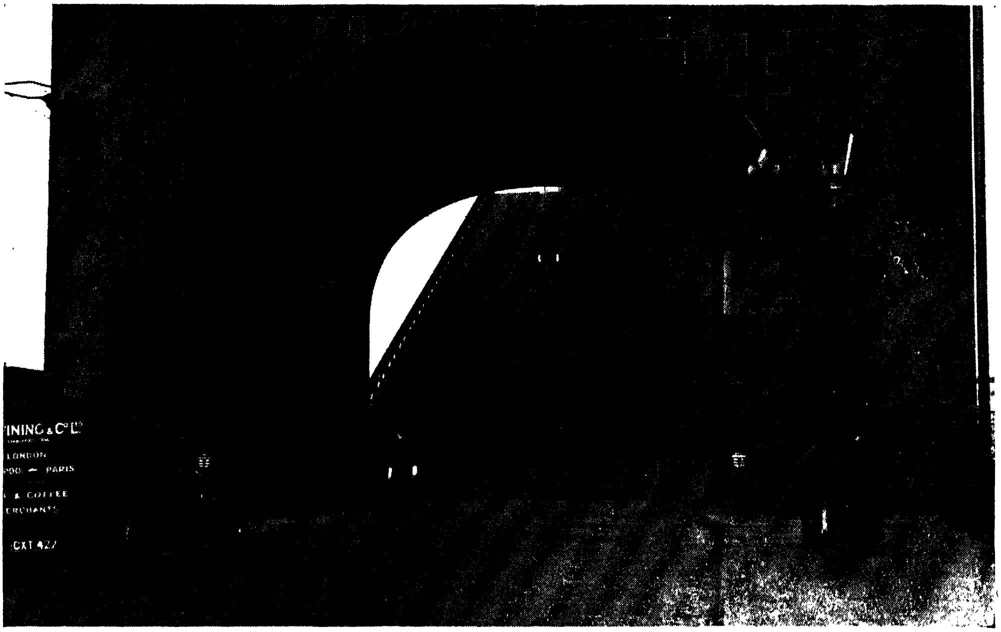
Example:

If macadam costs 24/- cu. yd., calculate tender rate per cu. yd. to show 20% gross for macadam laid 3 ins. thick consolidated when labour rate is 2/6 per hour, roller 8/6 per hour, and water-cart 1/- per hour, and material delivery guaranteed at 4 cu. yds. per hour.

Material cost	24/-	cu. yd.
Add 25% bulkage	6/-	,,
Labourer hours from tables, 1·90 at 2/-	3/10	,,
6–8 ton roller hours from tables, 0·25 at 8/6	2/1½	,,
Water-cart hours from table, 0·25 at 1/-	-/3	,,
∴ Cost	36/2½	,,
Add 20%	7/2½	
Tender price =	43/5	cu. yd.

∴ 3 ins. = 3/7½ sq. yd.

Note.—Water-cart is usually manhandled or drawn by roller.



The Acme Flooring and Paving Co. (1904) Ltd.

FIG. 40.—TOWER BRIDGE, LONDON

The special problems of surfacing bridge bascules have been met by end grain wood paving interlocked homogeneously and then secured to the lifting surfaces.

WORK TO FOOTWAYS

Note.—(1) In the case of Artificial Stone. Brick, Crazy and Tile Paving the Hours shown do *not* allow for "Knocking Up" mortar.

(2) In the case of "Concrete in Situ" Paving allow for Side Forms, Bullnosing and Curing. See page 250. For concrete Edging to Paths see page 204.

Description	*Unit*	*Percentage to add to materials to allow for consolidation*	*Sq. yds. tarmac laid per ton of material*		*2 ton petrol roller hours*	*Mason hours*	*Labourer hours*
			Limestone	*Slag*			
Excavation.—See Section No. 13							
Trim formations	Sq. yd.	—	—	—	—	—	0·08
2 in. Ashes or clinker	cu. yd.	33⅓%	—	—	0·29	—	1·10
3 in. ,, ,, ...	,,	33⅓%	—	—	0·25	—	1·00
4 in. ,, ,, ...	,,	33⅓%	—	—	0·22	—	0·90
4 in. hardcore, broken brick, etc. ..	,,	33⅓%	—	—	0·25	—	1·50
6 in. ,, ,, ,, ...	,,	33⅓%	—	—	0·19	—	1·10
2 in. artificial stone paving	sq. yd.	—	—	—	—	0·30	0·30
2½ in. ,, ,, ,, ..	,,	—	—	—	—	0·40	0·40
Brick paving on flat 9 × 4½ × 3 in.	,,	—	—	—	—	0·70	0·70
Tile paving 9 × 9 in.	,,	—	—	—	—	0·50	0·50
Quarry tiles 6 × 6 in.	,,	—		—	—	0·70	0·70
Crazy paving	,,	—	—	—	—	0·90	0·90
Concrete paving 4 in. thick ..	,,	—	—	—	—	—	0·70
,, ,, 6 in. thick ..	,,	—	—	—	—	—	1·00
¾ in. Granolithic paving	,,	—	—	—	—	0·25	0·25
1 in. ,, ,, ...	,,	—	—	—	—	0·30	0·30
2 in. gravel surfacing	cu. yd.	20%	—	—	0·32	—	2·10
3 in. ,, ,, ...	,,	20%	—	—	0·28	—	1·70
1 in. tarmacadam	sq. yd.	—	24·00	23·30	0·026	—	0·14
1½ in. ,, ...	,,	—	16·00	15·60	0·028	—	0·16
2 in. ,, ...	,,	—	12·00	11·70	0·030	—	0·18
2½ in. ,, ...	,,	—	9·80	9·50	0·032	—	0·20
Tardress paths one coat and grit ..	,,	—	—	—	0·020	—	0·16
Grass turves laid and rolled to verge	,,	—	—	—	—	—	0·25
Timber edging 4½ × 1¼ in.	lin. yd.	—	—	—	—	—	0·20
,, ,, 5 × 1½ in.	,,	—	—	—	—	—	0·25

For Edging to Quick Sweep use a Labour Multiplier of 1·50 with the Labour Hours shown.

***Table showing area of carriageway at road junctions with different radii of kerb, is given on page** 278.*

ROAD GULLIES AND GRATINGS

Size of gulley pot	*Volume of concrete surround cu. yds.*	*Excavation Labourer hours*	*Off-load and fix pot. lab. hours*	*Concrete surround Labourer hours*	*Fix gratings and frames*	
					Bricklayer hours	*Labourer hours*
18 ins. dia. by 4 ft.	1·00	7·20	1·80	5·00	1·60	1·60
18 ins. dia. by 3 ft. 6 ins. ..	0·90	6·20	1·70	4·50	1·60	1·60
18 ins. dia. by 3 ft.	0·80	5·20	1·60	4·00	1·60	1·60
18 ins. dia. by 2 ft. 6 ins. ..	0·70	4·20	1·50	3·50	1·60	1·60
15 ins. dia. by 3 ft.	0·60	3·80	1·50	3·00	1·50	1·50
15 ins. dia. by 2 ft. 6 ins. ..	0·52	3·30	1·40	2·60	1·50	1·50
15 ins. dia. by 2 ft.	0·44	2·80	1·30	2·20	1·50	1·50
12 ins. dia. by 2 ft. 6 ins. ..	0·47	3·00	1·30	2·40	1·40	1·40
12 ins. dia. by 2 ft.	0·40	2·50	1·20	2·00	1·40	1·40

SUNDRY WORKS TO ROADS

	Unit	*Labourer hours*	*Hours*	
			Roller	*Lorry standing being loaded*
Erect split chestnut fencing	lin. yd.	0·30	—	—
Laying sleeper road, off-load and lay	sleeper	0·30	—	—
Remove existing kerb and concrete	lin. yd.	0·50	—	—
Remove wood-block paving on concrete	sq. yd.	0·22	—	—
Scarify waterbound roads *not* tar-dressed and load into lorries 2 ins. deep	,,	0·13	0·015	0·002
Ditto. ditto. 3 ins. deep	,,	0·135	0·02	0·003
Scarify waterbound roads, tar-dressed, and load into lorries 2 ins. deep	,,	0·14	0·02	0·002
Ditto. ditto. 3 ins. deep	,,	0·146	0·024	0·003
Scarify tarmac roads, 2 ins. deep	,,	0·15	0·025	0·002
,, ,, ,, 3 ins. deep	,,	0·157	0·032	0·003
Roll to camber and falls ready for new surfacing material with mechanical roller	,,	nil	0·01	—
Strip turf and relay afterwards	,,	0·65	—	—
Sow grass seed	,,	0·02	—	—

Roads in Wood Block Paving

These roads consist of wood block paving superimposed on a concrete foundation and then grouted in. For the excavation for these and the concrete work involved also for breaking out existing roads, concrete, etc., reference should be made to the sections devoted to them, viz.:

"Excavator above Ground" (Section Thirteen).

"Concretor" (Section Twelve).

It should be particularly noted that this type of road is usually laid in built-up areas such as cities and that extensive watching and lighting as well as the control of traffic by flagmen, "Stop" and "Go" boards or controlled red and green signals may be necessary. This might be quite a costly item and must be allowed for when estimating. The maintenance of rights-of-way for pedestrian traffic, shoppers and shops must be remembered and taken into consideration when estimating the cost of the work.

Description	*Unit*	*Pavior hrs.*	*Labourer hrs.*
Remove old wood block paving and load into lorries	sq. yd.	—	0·25
Clean for re-use old sound blocks	,,	—	0·40
Lay 1 in. thick cement mortar bed	,,	0·25	0·25
,, 1¼ in. ,, ,,	,,	0·30	0·30
,, 1½ in. ,, ,,	,,	0·35	0·35
Relay old blocks and grout in	,,	0·70	0·70
Lay 9×3×4 in. deep new wood block paving dipped, grouted with mastic and grouted up	,,	0·60	0·60
,, 9×3×4 in. deep new wood block paving with ⅛ in. splines grouted in mastic	,,	0·40	0·40
Raking, cutting	lin. ft.	0·12	0·12
Circular cutting	,,	0·16	0·16

Roads in Granite Sett Paving

This class of road is not now constructed to anything like the extent that it used to be, though in cities such as Aberdeen where the granite is readily available. great areas of these roads are in use. They are suitable for carrying heavy traffic of the steel-tyred type; for fish markets, depots, yards, etc. The weights of granite setts and the setts required per square yard are given on pages 267 and 268.

It should be noted that these roads usually exist or are constructed in built-up areas such as cities and that extensive watching and lighting as well as traffic control by flagmen, "Stop" and "Go" boards, or controlled red and green signal lights may be necessary. This might prove quite a costly item and must be allowed for when estimating. The maintenance of rights-of-way for pedestrian traffic, shoppers and shops should also not be lost sight of and must be taken into consideration when estimating the cost of the work.

The setts are usually laid on a layer of mortar 1 in. thick on a concrete foundation and then grouted up either with weak cement and sand brushed well into the joints or grouted up with mastic. In cases where the bottom is firm they are sometimes laid on a sand bed or mortar bed only and then grouted up, but this is not general in cases where heavy traffic has to be carried.

A table of multipliers is shown for carrying out works to small areas such as in repair works to sunken areas.

If breaking out of existing roads, concrete, etc., is involved, reference should be made to "Excavator above Ground" (Section Thirteen), and for concreting to "Concretor" (Section Twelve).

Description	*Unit*	*Pavior hrs.*	*Labourer hrs.*
Remove old setts	sq. yd.	0·25	0·25
Clean for re-use old setts	,,	—	1·00
Lay 1 in. thick cement mortar bed	,,	0·25	0·25
,, 1¼ in. ,, ,,	,,	0·30	0·30
,, 1½ in. ,, ,,	,,	0·35	0·35
Relay old setts and grout joints with mortar swept in	,,	1·00	1·00
Lay new setts 4 × 4 in. deep, approx. 8 in. long, and grout in joints with cement mortar swept in	,,	0·80	0·80
Lay new setts 4 × 5 in. deep, approx. 8 in. long, and grout in joints with cement mortar swept in	,,	0·90	0·90
Raking cutting	lin. ft.	0·25	0·25
Circular cutting	,,	0·36	0·36

TABLE OF MULTIPLIERS FOR USE WITH ABOVE
TABLE FOR SMALL AREAS OF REPAIR

Area sq. yds.	*Multiplier*
0–2	2·00
2–5	1·80
5–10	1·50
10–15	1·40
15–20	1·30

SECTION TWENTY-FIVE

★

SMITH AND FOUNDER

This section covers the type of work generally met with, such as fixing rolled joists, brackets, handrails, steel ladders, etc., and the sharpening of tools. Water barrel is also shown under this section for convenience, though this is really plumber's work and is embodied in that section also.

FIXING SUNDRY FITTINGS

Item	*Unit*	*Smith hours*	*Labourer hours*
Fix brackets to walls. C. sect. area up to 1 sq. in.	each	0·25	0·25
,, ,, ,, ,, ,, ,, 1 to 2 sq. ins.	,,	0·40	0·40
,, ,, ,, ,, ,, ,, 2 to 3 sq. ins.	,,	0·60	0·60
,, doors, heavy steel	per cwt.	0·60	0·60
,, grating in walls or ceilings	sq. ft.	0·25	0·25
,, handrail standards of galvanized iron pipe	each	0·25	0·25
,, ,, of galvanized piping	lin. ft.	0·25	0·25
,, steel ladders, up to 18 ins. wide	,,	0·50	0·50
,, ,, tanks	cu. ft.	0·25	0·25
Cut bar reinforcement, up to ⅜ in. dia.	cwt.	0·40	0·40
,, ,, ,, ⅜ to ⅝ in. dia.	,,	0·30	0·30
,, ,, ,, over ⅝ in. dia.	,,	0·25	0·25
Bend bar reinforcement, up to ⅜ in. dia.	,,	0·90	0·90
,, ,, ,, ⅜ to ⅝ in. dia.	,,	0·80	0·80
,, ,, ,, over ⅝ in. dia.	,,	0·20	0·70

LAY AND JOINT WROUGHT IRON SERVICE PIPING, PER LINEAL YARD IN TRENCHES. (SCREWED JOINTS)

Diameter inches	*Smith hours*	*Labourer hours*
½	0·08	0·08
¾	0·10	0·10
1	0·12	0·12
1¼	0·14	0·14
1½	0·16	0·16
2	0·18	0·18

LAY AND JOINT WROUGHT IRON SERVICE PIPING TO WALLS OF BUILDINGS, INCLUDING BENDS, ELBOWS, ETC., PER LINEAL YARD. (SCREWED JOINTS)

Diameter inches	*Smith hours*	*Labourer hours*
½	0·33	0·33
¾	0·40	0·40
1	0·46	0·46
1¼	0·55	0·55
1½	0·66	0·66
2	0·82	0·82

RAINWATER PIPES, GUTTERING, AND CISTERNS

Description	*Unit*	*Smith hours*	*Labourer hours*
Off-load and fix 4 in. gutter	lin. ft.	0·14	0·14
„ „ 5 in. „	„	0·18	0·18
„ „ 3 in. rainwater pipes	„	0·14	0·14
„ „ 4 in. „ „	„	0·18	0·18
„ „ shoes to down pipes	each	0·60	0·60
„ „ stop ends to gutters	„	0·20	0·20
„ „ W.C. cisterns and pans	„	2·80	2·80

SHARPENING TOOLS

Item	*Unit*	*Smith hours*	*Labourer hours*
Sharpen and temper medium-sized chisels	each	0·12	0·12
„ „ large chisels	„	0·25	0·25
„ „ medium-sized points up to 1 in. dia. bar	„	0·25	0·25
„ „ heavy points	„	0·40	0·40
„ „ drills for pneumatic tools	„	0·75	0·75
„ „ Points „ „	„	0·60	0·60
„ „ Picks (per end)	„	0·15	0·15
„ „ tines for scarifiers	„	0·35	0·35

Reinforcement

This may be either in flat sheets or bars, bent or otherwise and indented bars. The cost of fixing the latter is the same as for round bars.

FLAT SHEETS LAID IN VARIOUS CLASSES OF WORK PER SQUARE YARD

Weight in lb. sq. yd.	*Unit*	*To beams*	*To columns*	*To floors*	*To girder casings*	*To roads*	*To roofs*	*To walls*
1	Lab. hrs.	0·12	0·14	0·03	0·18	0·02	0·06	0·10
2	„	0·17	0·20	0·04	0·25	0·03	0·09	0·14
3	„	0·22	0·26	0·05	0·32	0·04	0·12	0·18
4	„	0·27	0·32	0·06	0·38	0·05	0·15	0·22
5	„	0·32	0·38	0·07	0·44	0·06	0·18	0·26
6	„	0·37	0·44	0·08	0·50	0·07	0·21	0·30
7	„	0·41	0·50	0·09	0·57	0·08	0·24	0·34
8		0·47	0·58	0·10	0·66	0·09	0·27	0·38

CUTTING FLAT SHEET REINFORCEMENT PER LINEAL FOOT

Weight of sheets lb. per sq. yd.	*Straight cutting Labour hours*	*Circular cutting Labour hours*
1	0·02	0·04
2	0·03	0·06
3	0·04	0·08
4	0·05	0·10
5	0·06	0·12
6	0·07	0·14
7	0·08	0·16
8	0·09	0·18

MULTIPLIERS FOR REINFORCEMENT LAID IN FLOORS OR ROOFS AT VARIOUS HEIGHTS ABOVE GROUND

Height above ground in feet	*Multiplier*
10	1·00
20	1·10
30	1·20
40	1·30

ROUND BAR REINFORCEMENT. FIXED COMPLETE. LABOUR HOURS PER CWT.

Description Dia. of bars	*Straight bars*						*Bent bars*					
	Walls		*Floors, roofs and beams*		*Columns and braces*		*Walls*		*Floors, roofs and beams*		*Columns and braces*	
	Steel Fixer hours	*Lab. hours*	*Steel Fixer hours*	*Lab. hours*	*Steel Fixer hours*	*Lab. hours*	*Steel Fixer hours*	*Lab. hours*	*Steel Fixer hours*	*Lab. hours*	*Steel Fixer hours*	*Lab. hours*
Up to ⅜ in. ..	3·0	3·6	2·0	2·6	3·3	3·9	3·5	4·1	2·5	3·1	3·8	4·4
⅜ in. and ½ in.	1·7	2·3	1·2	1·8	2·0	2·6	2·3	2·9	1·7	2·3	2·6	3·2
½ in. to ¾ in...	1·4	2·0	1·0	1·6	1·7	2·3	1·9	2·5	1·5	2·1	2·2	2·8
Over ¾ in. ..	1·0	1·6	0·70	1·3	1·3	1·9	1·5	2·1	1·2	1·8	1·8	2·4

LABOUR HOURS TO ADD PER CWT. TO THE PREVIOUS TABLE IF BAR REINFORCEMENT IS HOISTED OR LOWERED

Depth hoisted or lowered in feet	*Labour hours to add per cwt. and diameter of bars*			
	Up to ⅜ in.	*⅜ in. to ½ in.*	*½ in. to ¾ in.*	*Over ¾ in.*
10	0·20	0·17	0·14	0·11
20	0·28	0·24	0·20	0·16
30	0·36	0·31	0·26	0·21
40	0·44	0·38	0·32	0·26
50	0·52	0·45	0·38	0·31

SUNDRY WORKS TO STRUCTURAL STEELWORK

Description	*Fitter hours*	*Labour hours*
Cutting to girders, etc., per sq. in. cross sectional area	0·20	0·20
Holes ½ in. dia. up to ½ in. plate. Each	0·20	0·20
Holes ¾ in. dia. up to ½ in. plate. Each	0·25	0·25
Holes 1 in. dia. up to ½ in. plate. Each	0·30	0·30
Holes ½ in. dia. over ½ in. and up to ¾ in. plate. Each	0·30	0·30
Holes ¾ in. dia. over ½ in. and up to ¾ in. plate. Each	0·38	0·38
Holes 1 in. dia. over ½ in. and up to ¾ in. plate. Each	0·45	0·45
Bolted connections, ½ in. bolts. Each	0·10	0·10
Bolted connections, ¾ in. bolts. Each	0·12	0·12
Bolted connections, 1 in. bolts. Each	0·15	0·15

STRUCTURAL STEELWORK

Note.—(1) The data shown refer to the erection of new work. For steelwork in alterations, see table below.

(2) For sundry works in connection with structural steelwork, see p. 262.

Description	*Steelwork fixed per cwt.*							
	Plain steelwork Unjointed		*Steelwork Jointed*		*Compound beams and stancheons*		*Roof trusses*	
	Fitter hours	*Labour hours*	*Fitter hours*	*Labour hours*	*Fitter hours*	*Labour hours*	*Fitter hours*	*Labour hours*
Fix and erect at ground-floor level	0·24	0·24	0·73	0·73	0·98	0·98	—	—
Fix and erect 10 ft. above ground level ..	0·53	0·53	1·06	1·06	1·41	1·41	1·94	1·94
Fix and erect 20 ft. above ground level ..	0·56	0·56	1·11	1·11	1·48	1·48	2·03	2·03
Fix and erect 30 ft. above ground level ..	0·58	0·58	1·16	1·16	1·55	1·55	2·12	2·12
Fix and erect 40 ft. above ground level ..	0·61	0·61	1·22	1·22	1·63	1·63	2·23	2·23
Fix and erect 50 ft. above ground level ..	0·64	0·64	1·27	1·27	1·69	1·69	2·33	2·33

STEELWORK IN ALTERATIONS

Note.—(1) The data shown are for work carried out in alterations as distinct from new structura steelwork.

(2) For sundry works in connection with steelwork, see p. 262.

Description	*Steelwork fixed per cwt.*							
	Plain steelwork Unjointed		*Steelwork Jointed*		*Compound beams and stancheons*		*Roof trusses*	
	Fitter hours	*Labour hours*	*Fitter hours*	*Labour hours*	*Fitter hours*	*Labour hours*	*Fitter hours*	*Labour hours*
Fix and erect at ground-floor level	0·58	0·58	1·80	1·80	2·40	2·40	—	—
Fix and erect 10 ft. above ground level ..	1·15	1·15	2·30	2·30	3·07	3·07	4·21	4·21
Fix and erect 20 ft. above ground level ..	1·21	1·21	2·42	2·42	3·21	3·21	4·43	4·43
Fix and erect 30 ft. above ground level ..	1·27	1·27	2·53	2·53	3·37	3·37	4·63	4·63
Fix and erect 40 ft. above ground level ..	1·33	1·33	2·65	2·65	3·53	3·53	4·85	4·85
Fix and erect 50 ft. above ground level ..	1·38	1·38	2·76	2·76	3·68	3·68	5·05	5·05

SECTION TWENTY-SIX

TILER AND SLATER

The work in this section covers such roofings as corrugated asbestos sheets, corrugated iron, felting and slating and tiling, these being the materials most commonly met with. In actual practice the civil engineer does little roofing work, but there are instances, such as the building of pump-houses, where roofing has to be considered. The data in this section has been kept as concise and simple as possible.

There are many firms throughout the country who specialise in roofing work, and if a large amount of such work is included in the estimate of a civil engineering contract the roofing work might with advantage be sub-let to one of these firms. The estimator should therefore call for outside tenders for the roofing work from two or three of these firms and base his own estimate on these, adding a percentage addition to allow for overhead charges and profit. In the event of his securing the contract he can then sub-let the roofing if this is desirable, and obtain an assured profit. The percentage addition would, in all probability, range from 5% to 10%.

FIX CORRUGATED ASBESTOS ROOF SHEETING—LIGHT TYPE PER SQUARE YARD

Sheets 2 ft. 6 ins. wide and 6 ins. end laps, and one side lap

Length of sheets in feet	*Area of roof covered by one sheet sq. yds.*	*Unit*	*Roofer Hours per sq. yd.*	*Labourer Hours per sq. yd.*
4	0·82	sq. yards	0·25	0·25
5	1·06	,,	0·24	0·24
6	1·30	,,	0·23	0·23
7	1·53	,,	0·22	0·22
8	1·76	,,	0·21	0·21

ROOFER AND LABOURER HOUR MULTIPLIERS FOR USE WITH THE ABOVE TABLE

Description	*Roofer and labourer hour multipliers*
Light type sheets, 2 ft. 6 ins. wide	1·00
,, ,, ,, 3 ft. 6 ins. wide	0·90
Heavy type sheets, 3 ft. 6 ins. wide	1·30

CORRUGATED IRON ROOFS

Off-load and fix Corrugated Iron to Roofs per 100 sq. ft. of Roof

	Hours
Carpenter	2·30
Labourer	2·30

FELT ROOFS

Off-load and Fix Felt to Roofs per 100 sq. ft. of Roof

	Hours
Carpenter	1·50
Labourer	1·50

ASBESTOS ROOFING—SUNDRY WORKS

Item	*Unit*	*Roofer hours*	*Labourer hours*
Fix aprons, 44 ins. wide	lin. ft.	0·10	0·10
„ barges	„	0·08	0·08
„ corners	„	0·07	0·07
„ eaves	„	0·07	0·07
„ hips. Light type	„	0·12	0·12
„ „ Heavy „	„	0·20	0·20
„ ridges. Two-piece. Light type	„	0·10	0·10
„ „ „ Heavy „	„	0·16	0·16
„ valleys	„	0·08	0·08

PLAIN TILING TO ROOFS

Note.—(1) Tiles are 10½ × 6½ in. nailed every 5th course with battens at 16 in. centres.
(2) The data shown is per square of 100 sq. feet of roof.
(3) Allow 5% waste on battens, nails and tiles.

Gauge of tiles in inches	*Material required per 100 sq. ft. of roof*				*Fix battens per square of roof*		*Fix tiles per square of roof*	
	Battens lin. ft.	*Batten nails lbs.*	*Tiles No.*	*Tile nails lbs.*	*Carpenter hrs.*	*Lab hrs.*	*Tiler hrs.*	*Lab hrs.*
3¼	370	2·30	682	1·50	3·00	1·50	5·90	5·90
3½	343	2·20	633	1·40	2·80	1·40	5·50	5·50
3¾	320	2·00	590	1·30	2·60	1·30	5·20	5·20
4	300	1·80	554	1·20	2·40	1·20	5·00	5·00

SUNDRY WORK TO PLAIN TILING

Item	*Unit*	*Tiler hrs.*	*Lab. hrs.*
Cement fillets	lin. ft.	0·06	0·06
Eaves course bedded in mortar	„	0·03	0·03
Hips and valleys—cutting (both sides measured)	„	0·10	0·10
Pointing verges	„	0·06	0·06
Cutting to verges, gables, etc.	„	0·12	0·12

PANTILING TO ROOFS

Note.—(1) The data shown is for 13½ × 9¾ in. tiles laid to 3 in. lap per square of 100 square feet of roof.
(2) Allow 5% waste on battens, nails and tiles.

No. tiles reqd. per square of roof	*Battens reqd. per square of roof lin. ft.*	*Batten nails reqd. per square of roof lbs.*	*Fix battens per square of roof*		*Fix tiling per square of roof*	
			Carpenter hrs.	*Lab. hrs.*	*Tiler hrs.*	*Lab. hrs.*
164	110	0·70	0·90	0·45	1·30	1·30

SUNDRY WORK TO PANTILING

Item	*Unit*	*Tiler hrs.*	*Lab. hrs.*
Eaves course bedded in mortar	lin. ft.	0·03	0·03
Hips and valleys—cutting (both sides measured)	„	0·20	0·20
Cutting to verges, etc.	„	0·18	0·18
Fix hip or ridge tiles	„	0·25	0·25

SLATING TO ROOFS

Note.—(1) Allow 5% waste on battens, nails and slates.
(2) The data shown is per square of 100 square feet of roof and for slates laid to a 3 in. lap.

Name and size of Slate	*Material reqd. per 100 sq. ft. of roof*				*Fix battens per square of roof*		*Fix slates per square of roof*	
	Battens lin. ft.	*Batten nails lbs.*	*Slates No.*	*Slate nails lbs.*	*C'penter hours*	*Lab. hours*	*Slater hours*	*Lab. hours*
Duchess 24 × 12 in. ..	116	0·70	115	1·90	0·92	0·46	1·80	1·80
Marchioness 22 × 11 in.	128	0·80	138	2·10	1·02	0·51	2·20	2·20
Countess 20 × 10 in. ..	142	0·90	170	2·80	1·14	0·57	2·60	2·60
Viscountess 18 × 9 in. ..	160	1·00	213	3·60	1·28	0·64	3·20	3·20
Ladies 16 × 8 in. ..	186	1·20	277	4·60	1·48	0·74	4·20	4·20

SUNDRY WORK TO SLATING

Item	*Unit*	*Slater hours*	*Labourer hours*
Bedding to eaves per course	lin. ft.	0·03	0·03
„ verges	„	0·04	0·04
Cement fillets	„	0·06	0·06
Pointing and filleting	„	0·06	0·06
Rendering and torching under slates	sq. ft.	0·04	0·04
Cutting to valleys and gutters (both sides measured)	lin. ft.	0·24	0·12
„ „ eaves (both sides measured)	„	0·16	0·08
„ „ hips „ „ „	„	0·36	0·18
„ „ ridges „ „ „	„	0·18	0·09

SECTION TWENTY-SEVEN

★

USEFUL TABLES

WEIGHT OF VARIOUS MATERIALS—TONS PER CUBIC YARD

Material	*Tons per cu. yd.*
Ashes	0·64
Ballast	1·22
Clinker	0·54
Cement	1·10
Granite, 1½ to ½ in.	1·08
Hardcore bricks	0·94
„ stone	1·20
Limestone, 1½ to ½ in.	1·00
Media for filters	0·66
Sand, pit	1·15
„ washed	1·20
Shale	1·02
Shingle, 1½ to ½ in.	1·12
„ ¾ to ⅛ in.	1·08

WEIGHT OF AGGREGATES—TONS PER CUBIC YARD

Size inches	*Crushed shingle*	*Broken limestone*	*Broken granite*
2½	1·18	1·06	1·11
2	1·16	1·04	1·10
1½	1·14	1·02	1·09
1	1·12	1·00	1·08
¾	1·10	0·98	1·06
½	1·08	0·96	1·04
⅜	1·06	0·94	1·02
¼	1·04	0·92	1·00

WEIGHT OF GRANITE SETTS. TONS PER SQUARE YARD

Size of setts in inches	*Tons per lin. yd. Single row*	*Tons per sq. yd.*
3 by 3 deep ..	0·013	0·14
3 by 4 „ ..	0·020	0·18
3 by 5 „ ..	0·024	0·25
3 by 6 „ ..	0·026	0·28
4 by 4 „ ..	0·025	0·18
4 by 5 „ ..	0·030	0·25
4 by 6 „ ..	0·038	0·28
5 by 5 „ ..	0·04	0·25
5 by 6 „ ..	0·05	0·28

WEIGHT OF KERB. TONS PER LINEAL YARD

Size of kerb in inches	*Granite tons lin. yd.*	*Concrete tons lin. yd.*
12 by 8 ..	0·15	0·12
12 by 6 ..	0·11	0·09
10 by 8 ..	0·12	0·10
10 by 6 ..	0·09	0·08
10 by 5 ..	0·08	0·07
10 by 4 ..	0·07	0·06
7 by 2 ..	0·023	0·02
5 by 2 ..	0·012	0·01

SETT PAVING

One ton setts	Sq. yds.	Per square yard			
		No. of stones	Weight cwts.	qrs.	lb.
3 × 3 in. covers	7⅔	86	2	2	0
3 × 4 ,,	5½	43	3	2	0
3 × 5 ,,	4¼	47	4	2	0
3 × 6 ,,	4	40	5	0	0
3 × 7 ,,	3¼	43	6	0	0
4 × 4 ,,	5½	61	3	2	0
4 × 5 ,,	4	37	4	3	0
4 × 6 ,,	3½	35	5	1	0
4 × 7 ,,	3¼	30	6	0	0
4 × 9 ,,	2½	30	8	0	0
5 × 5 ,,	4	33	5	0	0
5 × 6 ,,	3½	29	5	3	0
5 × 7 ,,	3	25	6	2	0

Depth of setts 5 in., which is the depth now generally specified.

WEIGHTS OF MATERIALS

Material	lb. per cu. ft.
Asphalt (without grit)	137 lb.
Asphalt (rock)	100 ,,
Ballast and sand (dry, loose)	95–110 ,,
Bitumen	65–80 ,,
Basalt	175–180 ,,
Cement (ordinary)	90 ,,
Cement (rapid hardening)	84 ,,
Cement (aluminous)	90 ,,
Chalk	140 ,,
Clay (solid)	120 ,,
Concrete (average)	135 ,,
Earth (common loam)	75 ,,
Flint	162 ,,
Granite	165 ,,
Cast iron	450 ,,
Lead	710 ,,
Lime	25–35 ,,
Limestone	161 ,,
Marble	175 ,,
Oak	59 ,,
Portland stone	151 ,,
Sandstone	150–160 ,,
Salt (loose)	60 ,,
Slate (Welsh)	180 ,,
Snow (freshly fallen)	5–12 ,,
Kentish ragstone	165 ,,
Traprock	170 ,,
Tar	63 ,,
Whinstone	175 ,,
Purbeck stone	162 ,,
Pitch	72 ,,
India-rubber	60 ,,
Brickwork (in cement)	130–140 ,,

PAVING-TILES PER YARD SUPER

Dimensions of Tiles	No. per Yard Super
2′ 0″ × 2′ 0″	2¼
1′ 6″ × 1′ 6″	4
1′ 0″ × 1′ 0″	9
1′ 0″ × 6″	18
1′ 0″ × 3″	36
6″ × 3″	72
8″ × 8″	20¼
9″ × 3″	48
6″ × 1″	216
6″ × 2″	108
4″ × 4″	81
2″ × 2″	324

YORK AND PURBECK STONE PAVING

York

70 ft. super 2½ in. thick equals 1 ton
58 ,, 3 ,, ,, ,,
43 ,, 4 ,, ,, ,,
86 ,, 2 ,, ,, ,,

Purbeck

83 ft. super 2 in. thick equals 1 ton
66 ,, 2½ ,, ,, ,,
55 ,, 3 ,, ,, ,,

Granite

54 ft. super 3 in. thick equals 1 ton

GRANITE KERBING

Dimensions	Feet per ton
12 × 8 in. (laid flat)	20
10 × 8 ,, ,,	24
10 × 6 ,, ,,	32
12 × 6 ,, ,,	27
5 × 10 ,, (edge)	37
6 × 10 ,, ,,	33
5 × 12 ,, ,,	33
6 × 12 ,, ,,	28

In describing kerb it is customary to state the width first and the depth second.

WEIGHT OF ARTIFICIAL STONE PAVING TONS PER SQUARE YARD

Thickness of stone	*Tons per sq. yd.*
2 ins. . .	0·10
2½ „ . .	0·13

WEIGHT OF STEEL PLATE IN POUNDS PER SQUARE FOOT

Thickness of plate	*lb. per sq. ft.*
1/16	2·50
⅛	5
¼	10
⅜	15
½	20
⅝	25
¾	30
⅞	35
1″	40

WEIGHT OF VARIOUS PIPES TONS PER LINEAL YARD

Diameter in inches	*Stoneware pipes tons per lin. yd.*	*Concrete tubes tons per lin. yd.*
3	—	—
4	0·01	—
5	—	—
6	0·02	—
7	—	—
8	—	—
9	0·03	0·08
12	0·06	0·11
15	0·09	0·15
18	0·13	0·18
21	0·17	0·22
24	0·22	0·30
27	0·29	0·34
30	0·33	0·41
33	0·42	0·48
36	0·50	0·56

WEIGHT OF ROLLED STEEL TEES AND ANGLES PER LINEAL FOOT

Tees and angle size, breadth of flanges added—inches	*lb. per lin. ft.*
2	2·03
3	3·28
4	4·53
5	5·80
6	7·03
7	9·57
8	11·03
9	14·17
10	15·83
11	17·50
12	19·17

WEIGHT OF STEEL TUBES

BSS. 1387. *New Standard*

Note.—The weight of screwed and socketed tube is based on:
15 ft. length for ⅛ in. nominal bore.
19 ft. length for ¼ in. and upwards nominal bore.

Nominal bore in.	*Approx. outside dia. in.*	*Weight per foot in lbs. ends*					
		Plain ends			*Screwed and socketed ends*		
		Class A	*Class B*	*Class C*	*Class A*	*Class B*	*Class C*
⅛	13/32	0·244	0·273	0·328	0·247	0·276	0·331
¼	17/32	0·348	0·391	0·482	0·351	0·393	0·484
⅜	11/16	0·455	0·573	0·693	0·459	0·577	0·696
½	27/32	0·643	0·825	0·982	0·650	0·831	0·987
¾	1 1/16	0·941	1·173	1·413	0·951	1·182	1·421
1	1 11/32	1·349	1·651	2·009	1·364	1·664	2·020
1¼	1 11/16	1·729	2·357	2·821	1·751	2·375	2·836
1½	1 29/32	2·201	2·988	3·520	2·233	3·015	3·544
2	2⅜	2·779	3·795	4·488	2·827	3·836	4·524
2½	3	3·893	5·301	6·304	3·979	5·375	6·370
3	3½	4·577	6·246	7·442	4·700	6·354	7·540
3½	4	5·878	7·712	8·557	6·006	7·288	8·660
4	4½	6·647	8·117	9·695	6·831	8·286	9·847

WEIGHT OF ROUND AND SQUARE STEEL BARS

Size inches	*Round*		*Square*		*Size inches*	*Round*		*Square*	
	lb. per lin. ft.	*lin. ft. per cwt.*	*lb. per lin. ft.*	*lin. ft. per cwt.*		*lb. per lin. ft.*	*lin. ft. per cwt.*	*lb. per lin. ft.*	*lin. ft. per cwt.*
3/16	0·09	1192	0·17	658	1 3/4	8·02	14	10·21	11
1/4	0·16	667	0·21	533	2	10·47	11	13·33	8·4
5/16	0·26	428	0·32	350	2 1/4	13·25	8·5	16·87	6·64
3/8	0·37	297	0·47	238	2 1/2	16·35	7	20·83	5·38
7/16	0·50	218	0·64	175	2 3/4	19·80	5·65	25·21	4·44
1/2	0·65	167	0·83	135	3	23·56	4·75	30·00	3·73
9/16	0·85	133	1·03	109	3 1/4	27·65	4	35·21	3·18
5/8	1·02	107	1·30	86	3 1/2	32·07	3·5	40·83	2·73
11/16	1·26	89	1·53	73	3 3/4	36·82	3	46·87	2·39
3/4	1·47	74	1·87	60	4	41·89	2·68	53·33	2·10
13/16	1·76	64	2·14	52	4 1/4	47·29	2·37	60·21	1·86
7/8	2·00	54	2·55	44	4 1/2	53·01	2·1	67·5	1·66
15/16	2·35	48	2·84	40	4 3/4	59·07	1·9	75·21	1·49
1	2·62	42	3·33	33	5	65·45	1·74	83·33	1·34
1 1/8	3·31	34	4·22	26	5 1/4	72·16	1·55	91·87	1·21
1 1/4	4·09	28	5·21	21	5 1/2	79·19	1·4	100·83	1·10
1 3/8	4·95	22	6·30	18	5 3/4	86·56	1·29	110·21	1·00
1 1/2	5·89	19	7·50	15	6	94·25	1·18	120·00	0·93

WEIGHT OF ROLLED STEEL CHANNELS PER LINEAL FOOT

Note.—Size of main web given first in inches.

Size of channel	*lb. per lin. ft.*
12 by 3 1/2	30·60
10 by 4	27·40
9 by 3	18·50
8 by 3 1/2	23·80
7 by 3 1/2	22·10
7 by 3	20·40
6 by 3	15·70
4 1/2 by 2	11·30
4 by 3	16·40

WEIGHT OF ROLLED STEEL JOISTS PER LINEAL FOOT

R.S. Joists size in inches	*lb. per lin. ft.*
12 by 6	44
12 by 5	32
10 by 6	42
10 by 5	30
9 by 7	58
9 by 4	21
8 by 6	35
8 by 5	28
8 by 4	18
7 by 4	16
6 by 5	25
6 by 4 1/2	20
6 by 3	12
5 by 4 1/2	18
5 by 4	16
5 by 3	11
4 by 3	10
3 by 3	9

WEIGHT OF GALVANIZED CORRUGATED IRON

Measured net, including laps

B.W.G.	*Weight per square*			*Sq. ft. per ton*
	cwt.	*qrs.*	*b.*	
26	1	0	18	1,720
24	1	1	10	1,500
22	1	2	24	1,170
20	1	3	26	1,000
18	2	2	4	790
16	3	1	21	575

CORRUGATED IRON SHEETS

B.W.G.	*Weights per square*			*Sq. ft. per ton*
	cwts.	*qrs.*	*lb.*	
18	2	1	20	800
20	1	3	20	1020
22	1	2	7	1280
24	1	1	0	1530
26	1	0	7	2100

Covering Capacity and Weight per square when fixed. Width of Sheets 26 in.

FLAT BAR IRON POUNDS PER LINEAL FOOT

Width in inches	*Thickness in inches*									
	3/16	¼	5/16	⅜	7/16	½	⅝	¾	⅞	1
1	0·63	0·84	1·05	1·26	1·47	1·68	2·11	2·53	2·95	3·37
1⅛	0·71	0·95	1·18	1·42	1·66	1·90	2·37	2·84	3·32	3·79
1¼	0·79	1·05	1·32	1·58	1·84	2·11	2·63	3·16	3·68	4·21
1⅜	0·87	1·16	1·45	1·74	2·03	2·32	2·89	3·47	4·05	4·63
1½	0·95	1·26	1·58	1·90	2·21	2·53	3·16	3·79	4·42	5·05
1⅝	1·03	1·37	1·71	2·05	2·39	2·74	3·42	4·11	4·79	5·47
1¾	1·11	1·47	1·84	2·21	2·58	2·95	3·68	4·42	5·16	5·89
1⅞	1·18	1·58	1·97	2·37	2·76	3·16	3·95	4·74	5·53	6·32
2	1·26	1·68	2·11	2·53	2·95	3·37	4·21	5·05	5·89	6·74
2⅛	1·34	1·79	2·24	2·68	3·13	3·58	4·47	5·37	6·26	7·16
2¼	1·42	1·90	2·37	2·84	3·32	3·79	4·74	5·68	6·83	7·58
2⅜	1·50	2·00	2·50	3·00	3·50	4·00	5·00	6·00	7·00	8·00
2½	1·58	2·11	2·63	3·16	3·68	4·21	5·26	6·32	7·37	8·42
2⅝	1·66	2·21	2·76	3·32	3·87	4·42	5·53	6·63	7·74	8·84
2¾	1·74	2·32	2·89	3·47	4·05	4·63	5·79	6·95	8·10	9·26
2⅞	1·82	2·42	3·03	3·63	4·24	4·84	6·05	7·26	8·47	9·68
3	1·90	2·53	3·16	3·79	4·42	5·05	6·32	7·58	8·84	10·10
3¼	2·05	2·74	3·42	4·11	4·79	5·47	6·84	8·21	9·58	10·95
3½	2·21	2·95	3·68	4·42	5·16	5·89	7·37	8·84	10·32	11·79
3¾	2·37	3·16	3·95	4·74	5·53	6·32	7·89	9·47	11·05	12·63
4	2·53	3·37	4·21	5·05	5·89	6·74	8·42	10·10	11·79	13·47
4¼	2·68	3·58	4·47	5·37	6·26	7·16	8·95	10·74	12·53	14·31
4½	2·84	3·79	4·74	5·68	6·63	7·58	9·47	11·38	13·26	15·16
4¾	3·00	4·00	5·00	6·00	7·00	8·00	10·00	12·00	14·00	16·00
5	3·16	4·21	5·26	6·32	7·37	8·42	10·53	12·63	14·74	16·84
5¼	3·32	4·42	5·53	6·63	7·74	8·84	11·05	13·26	15·47	17·68
5½	3·47	4·63	5·79	6·95	8·10	9·26	11·58	13·89	16·21	18·52
5¾	3·63	4·84	6·05	7·26	8·47	9·68	12·10	14·53	16·95	19·37
6	3·79	5·05	6·32	7·58	8·84	10·15	12·63	15·16	17·68	20·21

Steel is approximately 2% heavier than iron.

CAST IRON S. AND S. SOIL, WASTE, VENTILATING AND HEAVY R.W. PIPES

British Standard Dimensions and Weights

	Extra heavy grade				*Heavy grade*				*Medium grade*						
	ins.	*ins.*	*ins.*	*ins.*	*ins.*	*ins.*	*ins.*	*ins.*	*ins.*	*ins.*	*ins.*	*ins.*	*ins.*	*ins.*	*ins.*
Nominal size	3½	4	5	6	3	3½	4	1½	2	2½	3	3½	4	5	6
Pipe internal diameter	3½	4	5	6	3	3½	4	1½	2	2½	3	3½	4	5	6
Pipe external diam.	4	4½	5½	6½	3 13/32	3 29/32	4 13/32	1⅞	2⅜	2⅞	3⅜	3⅞	4⅜	5⅜	6⅜
Thickness	¼	¼	¼	¼	13/64	13/64	13/64	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16
Socket internal diam.	4½	5	6⅛	7⅛	3 29/32	4½	5	2⅜	2⅞	3⅜	3 29/32	4½	5	6⅛	7⅛
Internal depth	3	3	3¼	3½	2¾	3	3	2¼	2½	2¾	2¾	3	3	3¼	3½
Weight of 6 ft. overall (no ears)	*lb.* 55	*lb.* 60	*lb.* 78	*lb.* 92	*lb.* 40	*lb.* 48	*lb.* 54	*lb.* 22	*lb.* 24	*lb.* 30	*lb.* 35	*lb.* 41	*lb.* 46	*lb.* 59	*lb.* 71

WIRE

S.W.G.	*Weight in lb. per 100 ft.*				*No. of yards in cwt. iron wire*
	Copper	*Brass*	*Aluminium*	*Iron*	
7/0	76·58	72·01	23·0	66·7	58
6/0	65·95	62·01	19·83	57·44	67
5/0	57·10	53·75	17·26	49·79	78
4/0	49·01	46·09	14·80	42·69	91
3/0	42·39	39·86	12·80	36·93	105
2/0	37·09	34·88	11·17	32·31	120
0	32·15	30·23	9·66	28·01	138
1	27·54	25·92	8·30	24·01	161
2	23·33	21·94	7·00	20·32	190
3	19·45	18·29	5·86	16·85	228
4	16·49	15·50	4·97	14·36	269
5	13·77	12·95	4·10	12·00	322
6	11·79	10·62	3·40	9·81	393
7	9·49	8·92	2·85	8·26	467
8	7·84	7·37	2·36	6·82	566
9	6·30	5·97	1·91	5·53	700
10	5·02	4·72	1·51	4·37	882
11	4·12	3·87	1·25	3·60	1,077
12	3·31	3·11	0·996	2·88	1,333
13	2·59	2·44	0·783	2·25	1,723
14	1·96	1·84	0·590	1·70	2,240
15	1·59	1·49	0·476	1·38	2,800
16	1·25	1·18	0·376	1·10	3,500
17	0·96	0·93	0·289	0·83	4,667
18	0·71	0·66	0·212	0·61	6,222
19	0·49	0·46	0·148	0·42	9,333
20	0·40	0·37	0·119	0·34	11,200
21	0·31	0·29	0·094	0·27	14,199
22	0·24	0·23	0·076	0·21	18,418
23	0·18	0·16	0·053	0·15	25,070
24	0·15	0,14	0·045	0·13	29,835
25	0·12	0·22	0·037	0·11	36,100
26	0·10	0·09	0·029	0·09	44,568

WEIGHT AND STRENGTH OF MATERIALS

Material	*lb. per cu. ft.*	*Ultimate strength tons per sq. in.*			*Yield point tons/sq. in.*	*Safe stress tons/sq. in.*	*Modulus of elasticity tons/sq. in.*
		Tension	*Com-pression*	*Shear*			
Cast iron ..	450	9	50	8	—	3	6,500
Malleable C.I. ..	450	18	—	—	—	—	—
Wrought iron ..	480	22	17	20	12	6	12,500
Cable iron ..	485	23	20	22	14	7	13,000
Mild steel ..	490	28	30	24	16	8	13,000
Cast steel ..	490	26	30	18	17	9	13,000
Spring steel ..	490	85	85	—	65	35	14,000
Gun-metal ..	540	14	30	10	8	—	5,000
Naval brass ..	530	22	—	—	11	—	—
Phosphor bronze	536	17	—	14	10	—	6,000
Manganese bronze	—	35	—	—	—	—	—
Lead	710	1	3	—	—	—	1,000
Duralumin ..	175	28	—	—	15	—	5,000

ASBESTOS CEMENT SHEETS

British Standard Dimensions

Flat sheets, feet	4 by 4	6 by 3	6 by 4	7 by 4	8 by 4
Thickness, inches	$\frac{5}{32}$ $\frac{3}{16}$ $\frac{1}{4}$	$\frac{5}{32}$ $\frac{3}{16}$ $\frac{1}{4}$	$\frac{5}{32}$ $\frac{3}{16}$ $\frac{1}{4}$	$\frac{5}{32}$ $\frac{3}{16}$ $\frac{1}{4}$	$\frac{5}{32}$ $\frac{3}{16}$ $\frac{1}{4}$ $\frac{5}{16}$ $\frac{3}{8}$

Corrugated sheets	*Width overall inches*	*Centre of corrugation inches*	*Depth of corrugation inches*	*Thickness inches*
Small Section Corrugations	29½	2$\frac{7}{8}$	1	$\frac{7}{32}$
	30	2$\frac{7}{8}$	1$\frac{1}{8}$	$\frac{7}{32}$
	42	2$\frac{7}{8}$	1$\frac{1}{8}$	$\frac{7}{32}$
	31½	3	1	$\frac{7}{32}$
Large Section Corrugations	41½	5¾	2$\frac{1}{8}$	¼
	41½	5¾	2	¼
	43	5¾	2	¼
	38	6	2	¼
Both types made 4 ft. to 10 ft. by 6 in. advances.				
Angular Section Corrugation	44	13·33	2	¼
	43¾	13·56	2	¼
	48	15·00	2	¼
Only the 44 in. sheet made in full range of lengths.				

MEASUREMENTS OF WATER

1 Imperial Gallon =	10 lb.
	16 cubic feet
	·277 cubic inches
	1·2 U.S. Gallons
	4·54 Litres
1 U.S. Gallon	8·33 lb.
1 Litre	2·2 lb.
	·035 cubic foot
	61 cubic inches
	·22 Imperial Gallon
1 Cubic Foot	6·23 Imperial Gallons
	28·33 Litres
	62·3 lb. Fresh Water
	64 lb. Salt Water
1 Ton (2,240 lb.)	36 cubic feet of Fresh Water
	224 Imperial Gallons of Fresh Water
	35 cubic feet Salt Water
	218 Imperial Gallons Salt Water

MENSURATION FORMULAE

AREA OF
CIRCLE = π (or 3·1416) by radius squared or square of diameter by 0·7854.
ELLIPSE = 0·7854 by long axis by short axis.

CIRCUMFERENCE OF
CIRCLE = π (or 3·1416) by diameter, or side of equal square by 3·545.
Circumscribing a square = side of square by 4·443.

DIAMETER OF
CIRCLE equal in area to square = Side of square by 1·1284.
Circumscribing square = Side of square by 1·414.

SIDE OF
Square equal in Area to Circle = diameter by 0·8862.
inscribed in circle = diameter of Circle by 0·707.

VOLUME OF
Circular Section (Ring), = Mean diameter of Ring by square of diameter of Section by 2·47.

HEAD OF WATER IN FEET AND EQUIVALENT IN POUNDS PER SQUARE INCH

Feet head	*Pressure per sq. in.*	*Feet head*	*Pressure per sq. in.*	*Feet head*	*Pressure per sq. in.*
1	0·43	36	15·59	71	30·75
2	0·86	37	16·02	72	31·18
3	1·30	38	16·45	73	31·62
4	1·73	39	16·89	74	32·05
5	2·16	40	17·32	75	32·48
6	2·59	41	17·75	76	32·92
7	3·03	42	18·19	77	33·35
8	3·46	43	18·62	78	33·78
9	3·89	44	19·05	79	34·21
10	4·33	45	19·49	80	34·65
11	4·76	46	19·92	81	35·08
12	5·20	47	20·35	82	35·52
13	5·63	48	20·79	83	35·95
14	6·06	49	21·22	84	36·39
15	6·49	50	21·65	85	36·82
16	6·93	51	22·09	86	37·25
17	7·36	52	22·52	87	37·68
18	7·79	53	22·95	88	38·12
19	8·22	54	23·39	89	38·55
20	8·66	55	23·82	90	38·98
21	9·09	56	24·26	91	39·42
22	9·53	57	24·69	92	39·85
23	9·96	58	25·12	93	40·28
24	10·39	59	25·55	94	40·72
25	10·82	60	25·99	95	41·15
26	11·26	61	26·42	96	41·58
27	11·69	62	26·85	97	42·01
28	12·12	63	27·29	98	42·45
29	12·55	64	27·72	99	42·88
30	12·99	65	28·15	100	43·31
31	13·42	66	28·58	150	64·97
32	13·86	67	29·02	200	86·63
33	14·29	68	29·45	250	108·20
34	14·72	69	29·88		
35	15·16	70	30·32		

ANGLES OF REPOSE

Vegetable soil	28°
Compact soil	50°
Loamy soil	40°
Compact loamy soil	50°
Gravel and sand mixed	40°
Clean shingle (loose)	39°
Soft dry clay	45°
Dry sand	38°

CUBIC FEET PER FOOT RUN

Size inches	*cu. ft.*	*Size inches*	*cu. ft.*	*Size inches*	*cu. ft.*
2¼×1	0·0156	8 ×8	0·4445	13 ×13	1·1735
3 ×2	0·0417	8 ×8½	0·4722	13 ×13½	1·2187
4 ×2	0·0556	8½×7½	0·4427	13½×12½	1·1719
4 ×3	0·0833	8½×8½	0·5017	13½×13½	1·2656
4 ×4	0·1111	9 ×3	0·1875	14 ×13½	1·3125
4¼×4¼	0·1255	9 ×6	0·375	14 ×14	1·3612
4½×4½	0·1406	9 ×8½	0·5312	14 ×14½	1·4097
5 ×2½	0·0868	9 ×9	0·5625	14½×13½	1·3593
5 ×3	0·1042	9 ×9½	0·5938	14½×14½	1·46
5 ×5	0·1736	9 ×12	0·75	15 ×14½	1·5104
5½×5½	0·2100	9½×8½	0·5608	15 ×15	1·5625
5½×6½	0·2483	9½×9½	0·6268	15 ×15½	1·6146
6 ×2	0·0834	10 ×9½	0·6597	15½×14½	1·5608
6 ×3	0·125	10 ×10	0·6944	15½×15½	1·6685
6 ×4	0·1667	10 ×10½	0·7291	16 ×8	0·8889
6 ×5½	0·2292	10½×9½	0·6927	16 ×12	1·3333
6 ×6	0·25	10½×10½	0·7656	16 ×15½	1·7222
6 ×6½	0·2709	11 ×4	0·3055	16 ×16	1·7777
6½×6½	0·2934	11 ×10½	0·8021	16 ×16½	1·8333
7 ×3	0·1458	11 ×11	0·8403	16½×15½	1·7761
7 ×6½	0·3160	11 ×11½	0·8785	16½×16½	1·8906
7 ×7	0·3402	11½×10½	0·8385	18 ×6	0·75
7 ×7½	0·3646	11½×11½	0·9183	18 ×9	1·125
7½×7½	0·3906	12 ×3	0·25	18 ×12	1·5
8 ×2½	0·1389	12 ×6	0·5	18 ×17	2·1251
8 ×3	0·1667	12 ×11½	0·9583	18 ×18	2·25
8 ×4	0·2222	12 ×12	1·00	18 ×19	2·375
8 ×5½	0·3055	12 ×12½	1·0417	20 ×19	2·6389
8 ×6	0·3334	12½×11½	0·9983	20 ×20	2·7779
8 ×6½	0·3612	12½×12½	1·0851	20 ×21	2·9167
8 ×7½	0·4167	13 ×12½	1·1285	24 ×24	4·00

VOIDS IN MATERIALS—PER CUBIC YARD

	Cubic ft.
Fine Pit Sand	6·35
Coarse Sea Sand	10·00
Gravel of ⅜ in. mesh	10·20
Clean shingle	10·00
Broken bricks, graded ¾ to 2½ in. ..	12·50
Broken stone: 1½ in. gauge	11·50
2 in. ,, ...	10·90
2½ in. ,, ...	10·30

BEARING VALUE OF SOILS

Description of Soil	*Approx. Bearing Value in Tons per sq.ft.*
Bog and peat	0 to 0·20
Loam marl, clay	3 to 7
Chalk	1 to 4
Rock	2 to 18
Coarse gravel	6 to 8
Fine gravel	4 to 6
Fine sand	2 to 5

SHRINKAGE OF MATERIALS

Materials increase in bulk when excavated and on being deposited shrink as follows:

Gravel	8%
Gravel and sand	9%
Clay and clayey earth	10%
Loam and light sandy soil	12%
Loose vegetable soil	15%

Wet soils shrink more than dry.
Rock increases in bulk when broken up and does not settle to less than its original volume. The increase in bulk is dependent upon the size of the broken pieces and varies between 40-60%.

COVERING CAPACITIES OF CEMENT MORTARS, ETC.

One Inch Thick

Neat	10·4 sq. ft.	= 1 cu. ft. loose.
1 cement: 1 sand	17·0 „	
1 „ 2 „	25·0 „	
1 „ 3 „	34·0 „	

1 cu. ft. of cement will make about:

4·1 cu. ft. concrete	1:2:4
5·0 „ „	1:2½:5
5.8 „ „	1:3:6
7.5 „ „	1:4:8

ANGLES OF SLOPES

Angle	*Slope*
18° 25′	3 to 1
26° 35′	2 to 1
33° 42′	1½ to 1
45° 0′	1 to 1
53° 0′	¾ to 1
56° 20′	⅔ to 1
63° 30′	½ to 1

VOLUMES OF MATERIALS

Sand and Aggregate:

1 Ton = 21 cu. ft. river sand.
= 22 cu. ft. pit sand.
= 22 cu. ft. ballast.
= 23 cu. ft. coarse gravel.
= 24 cu. ft. clean shingle.
= 28 cu. ft. marl.
= 19 cu. ft. stiff clay.
= 17 cu. ft. chalk.
= 29 cu. ft. chalk in lumps.
= 33 cu. ft. earth mould.

RUBBLE OR SLAG PITCHING

Thickness	*Area covered per ton in sq. yds.*
12 in.	2¼
10 „	3
9 „	3¼
8 „	3¾
6 „	4½

WEIGHTS, ETC., OF CRUSHED MATERIALS

Material	*Weight per cubic foot crushed lb.*	*Cubic feet per ton*
Granite	100	22·5
Limestone	94	24
Basalt	100	22·5
Sandstone	84	26·5
Hot blast slag	94	24
Cold blast slag	96	23
Clinker	50	45
Gravel	100	22·5
Kentish rag	103	22
Basaltic Whinstone	101	22·5

STANDARD SIZES FOR CONCRETE FLAGS

3′ 0″ × 2′ 0″ × 2″
3′ 0″ × 2′ 0″ × 2½″
2′ 6″ × 2′ 0″ × 2″
2′ 6″ × 2′ 0″ × 2½″
2′ 0″ × 2′ 0″ × 2″
2′ 0″ × 2′ 0″ × 2½″

Tolerance permitted ± 1/16″

1′ 6″ × 2′ 0″ × 2″
1′ 6″ × 2′ 0″ × 2½″

Slabs 2″ thick—1 ton covers 10 sq. yds.
2½″ „ 1 „ „ 8 „

They must be subjected to hydraulic pressure not less than 1,000 lb. per sq. in. over entire surface in manufacture.

WOOD BLOCKS

(AREA COVERED PER 1,000)

9 in. × 3 in. wide	21 sq. yds.
8 in. × 3 in. „	18·5 „
7 in. × 3 in. „	15 „

5% allowed for waste.

About 500 blocks per load.

APPROXIMATE WEIGHTS OF LEAD AND YARN FOR PIPE JOINTS

Size of pipe inches	*Caulking space inches*	*Depth of lead inches*	*Weight of lead lb.*	*Weight of yarn lb.*	*ozs.*
3	⅜	1¾	4	4	4½
4	⅜	1¾	4¾	0	6
5	⅜	1¾	5¾	0	10½
6	⅜	1¾	6¾	0	12
7	⅜	1¾	8	0	14
8	⅜	2	10	1	3
9	⅜	2	11¼	1	5
10	⅜	2	12½	1	7
12	⅜	2	14½	1	10
14	⅜	2½	20½	1	13
15	⅜	2½	22	1	15
16	⅜	2½	23½	2	1
18	7/16	2½	31	2	12
20	7/16	2½	34½	3	0
21	7/16	2½	36	3	2
24	7/16	2½	40	4	8
27	7/16	2½	45	5	0
30	7/16	2½	50	5	8
33	7/16	2½	55	6	0
36	7/16	2½	59½	6	10
38	7/16	2½	63	7	0
40	7/16	2½	66	7	4
42	7/16	2½	69	7	10

Note.—If a greater depth of lead is required, the weight will be proportionately greater.

MACADAM, ETC.

SQUARE YARDS/TON

Consolidated Thickness in inches	*Ashes*	*Slag*	*Granite*	*Whinstone*	*Slag Tarmacadam*	*Granite Tarmacadam*
4	8½	8	7	6	6	5½
3	11	10	9	8	8	7½
2	16½	16	14	12	12	11½
1	33	32	28	24	24	22½

One ton of dry slag blinding will cover about 200 yds. sup.

One gallon of tar—First coat covers 5 to 6 yds. sup.
Second coat covers 8 to 10 „

Paving bricks are usually 9 × 4½ × 1¾ in., and 36 bricks are required per yd. super. 100 weigh 14 cwts.

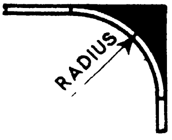
 RADIUS IN FEET	AREA OF SHADED AREA IN SQUARE YARDS
5	0·60
10	2·38
15	5·37
20	9·54
25	14·90
30	21·46
35	29·21
40	38·15

Table showing area of carriageway at road junctions with different radii of kerb.

CHANNELLING

10 × 4 in. flat will cover 39 ft. lin. per ton
10 × 6 „ „ „ „ 32 „ „
12 × 6 „ „ „ „ 27 „ „

CHANNELS—4 in. GRANITE CUBES

Length Covered per Ton

2 sett channel	20 yds. per ton
3 „	15 „
4 „	10 „

FLOW OF WATER IN STREAMS

Q = Quantity discharged per second.
A = Sectional area of waterway in stream.
F = Fall in a given length L.
P = Wetted perimeter, or girth of bottom and sides of open channel.
V = Velocity per second.
$V = 95\sqrt{\frac{A \times F}{P \times L}}$ feet per second.
$Q = A \times V$ cubic feet per second.

Note.—Applicable to streams and open channels only.

DATA RE WATER

1 cu. in. (62°F.)	weighs	0·0361 lb.
1 gallon	„	10·00 lb.
1 cu. ft.	„	62·355 lb.
1 cu. ft.	equals	6·2355 gallons
1 ton of water	„	224 gallons or 35·923 cu. ft.
1 cu. ft.	„	6·25 gallons
1 cu. ft. of ice	„	57·5 lb.

SAFE LOADS ON PIERS

Material	*Approx. Safe Load in Tons per sq. ft.*
Portland stone	13
Bath stone	6
Brick	5
Rubble masonry	4
Portland cement (concrete foundations)	10

EARTHENWARE PIPES, ETC.

Number of Pipes, etc., per Ton

Description		*Internal Diameter in Inches*					
		4 *in.*	6 *in.*	9 *in.*	12 *in.*	15 *in.*	18 *in.*
Pipes	Feet	270	162	90	54	36	24
Single Junctions	No.	120	65	45	24	12	9
Bends	No.	230	115	60	33	19	16
Double Junctions	No.	98	55	26	13	10	9

EARTHENWARE GULLIES

Size			*Number per ton*
Depth *ft.*	 *in.*	*Diameter.* *in.*	
2	6	12	17
3	0	12	16
2	6	15	12
3	0	15	10
3	6	15	9½
2	6	18	9
3	0	18	8
3	6	18	6⅔
4	0	18	6
4	6	18	4

Note.—Tables on Standard Weight of Spun Iron Spigot and Socket pipes, standard weight of cast iron Spigot and Socket vertically cast pipes, and weight of barrel of cast iron pipes are given under "Pipe-layer", Section Nineteen.

CIRCULAR SEWERS

Discharge through 9 in. dia. Pipe in Gallons per Minute

Gradient	*Depth of Flow in Proportion to Diameter of Pipe*			
	One-eighth	*One-quarter*	*One-half*	*Seven-eighths*
1 in 20	58	225	755	1,535
1 in 30	48	195	615	1,245
1 in 40	40	158	530	1,085
1 in 50	37	143	475	975
1 in 80	30	112	377	768
1 in 100	26	100	330	682

DISCHARGE THROUGH 12 IN. DIA. PIPE IN GALLONS PER MINUTE

Gradient	*Depth of Flow in Proportion to Diameter of Pipe*			
	One-eighth	*One-quarter*	*One-half*	*Seven-eighths*
1 in 30	98	380	1,275	2,580
1 in 40	86	330	1,100	2,236
1 in 50	76	292	980	2,000
1 in 80	60	235	725	1,580
1 in 100	53	212	690	1,412
1 in 200	38	145	490	1,000

DISCHARGE THROUGH 15 IN. DIA. PIPE IN GALLONS PER MINUTE

Gradient	*Depth of Flow in Proportion to Diameter of Pipe*			
	One-eighth	*One-quarter*	*One-half*	*Seven-eighths*
1 in 40	150	590	1,900	3,900
1 in 50	135	525	1,700	3,480
1 in 80	105	415	1,340	2,750
1 in 100	95	372	1,205	2,460
1 in 200	67	265	888	1,735
1 in 440	45	175	570	1,175
1 in 660	36	145	465	995
1 in 880	32	125	400	825

DISCHARGE THROUGH 18 IN. DIA. PIPE IN GALLONS PER MINUTE

Gradient	*Depth of Flow in Proportion to Diameter of Pipe*			
	One-eighth	*One-quarter*	*One-half*	*Seven-eighths*
1 in 50	210	830	2,684	5,500
1 in 66	182	685	2,380	4,775
1 in 80	164	625	2,120	4,336
1 in 100	147	575	1,903	3,885
1 in 200	105	414	1,342	2,745
1 in 440	70	272	907	1,845
1 in 880	50	192	640	1,302

BRICKWORK

A rod of brickwork = 306 cu. ft. or 11⅓ cu .yds.
= 272 ft. super of reduced brickwork 13½ in. thick.
= 408 ft. super 9 in. thick.

A rod of brickwork contains about 4,360 bricks and weighs about 16 tons.
A cubic foot of brickwork is equivalent to 14 bricks.
Closely stacked 1,000 bricks contain 56 cu. ft.
1,000 London stocks weigh 60¾ cwt.
Laid on edge 4,500 bricks will cover 100 sq. yds.
A pillar of brickwork should not exceed in height twelve times its least thickness.

VARIOUS BRICKS; WEIGHTS AND SIZES

Description	*Size*	*Weight per* 1,000 *in cwts.*
London stocks . .	8¾ × 4¼ × 2¾	60¾
Red kiln	8¾ × 4¼ × 2¾	63
Welsh firebricks . .	8¾ × 4½ × 2½	62½
Blue paving bricks . .	9 × 4½ × 3	80

QUANTITY OF BRICKWORK (LAID IN MORTAR) AND NUMBER OF BRICKS PER FOOT OF LENGTH

Half a Brick Thick			*One Brick Thick*	
Diameter in Feet	*No. of Bricks*	*Cu. ft. of Brickwork*	*No. of Bricks*	*Cu. ft. of Brickwork*
1·0	23	1·620	58	4·123
2·0	41	2·798	92	6·480
3·0	57	3·976	126	8·836
4·0	73	5·154	159	11·192
5·0	90	6·332	192	13·548
6·0	107	7·511	226	15·904
7·0	123	8·688	260	18·261
8·0	140	9·867	292	20·616
9·0	156	11·045	326	22·973
10·0	174	12·223	360	25·329

CRUSHING STRENGTH OF BRICKWORK AND BRICKS

Description	*Crushing Strength in tons/sq. ft*	
	Stocks	*Blue Staffordshire*
Bricks	84·27	701·10
Brickwork in lime mortar	14·34	74·30
Brickwork in cement mortar	14·93	87·94

TABLE SHOWING CEMENT AND SAND AND LIME AND SAND PER CUBIC YARD OF MORTAR

Mix	*Cement mortar*		*Lime mortar*	
	Cement tons	*Sand cu. yds.*	*Lime tons*	*Sand cu. yds.*
1 to 1	0·79	0·73	0·40	0·73
1 to 1½	0·67	0·93	0·33	0·93
1 to 2	0·54	1·00	0·27	1·00
1 to 2½	0·46	1·07	0·23	1·07
1 to 3	0·39	1·10	0·20	1·10
1 to 3½	0·33	1·15	0·17	1·15
1 to 4	0·29	1·20	0·15	1·20

Note.—The data shown relating to sand refers to dry sand. If washed sand is used a multiplier of 1·25 should be used in conjunction with the quantities of sand showh to allow for bulkage due to the moisture content.

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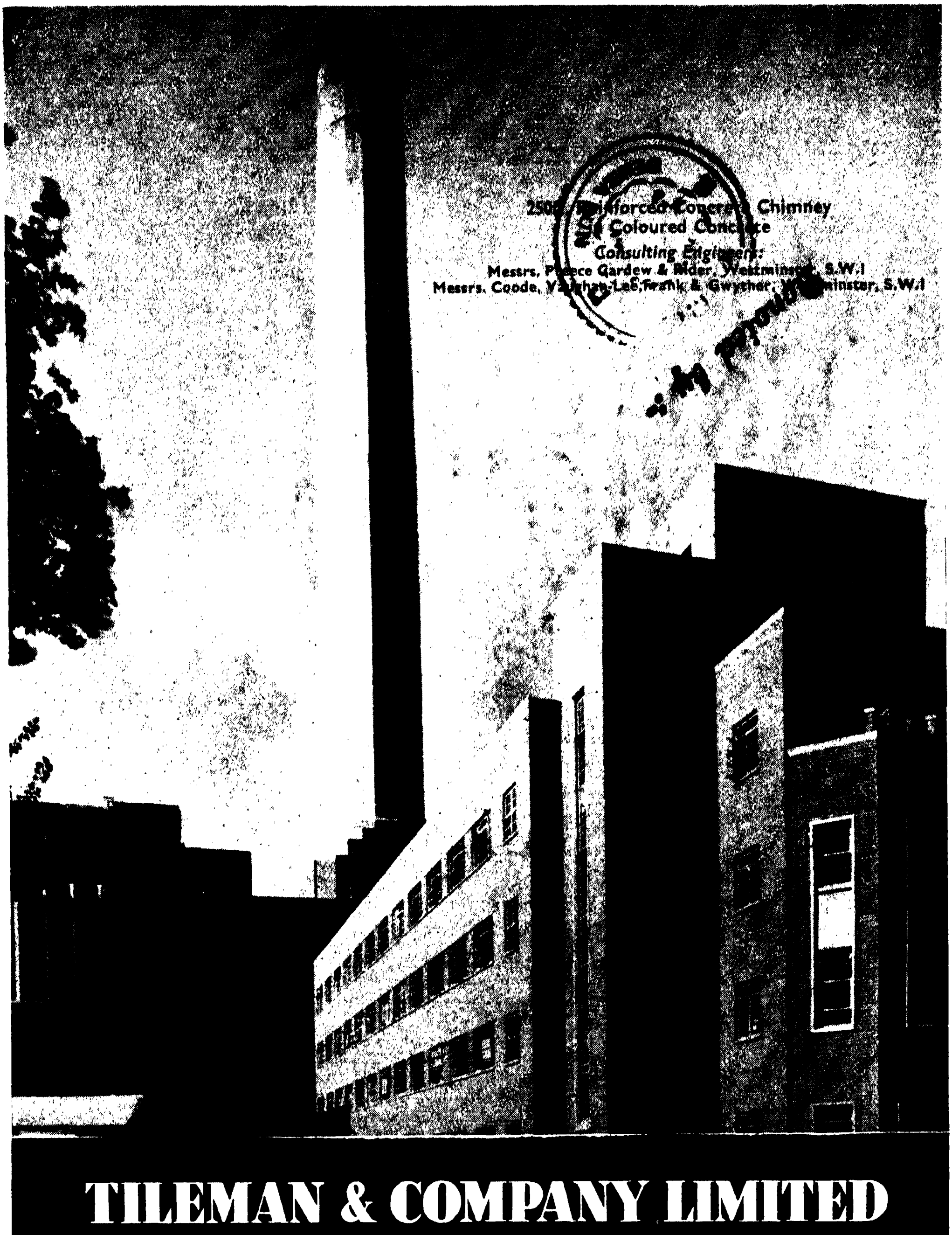

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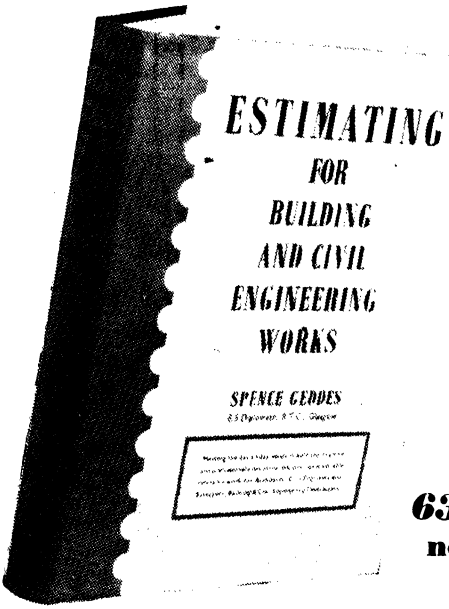

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